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Source Test and Evaluation Report--Exxon Miniplant Pressurized Fluidized-Bed Combustor with Sorbent Regeneration

GCA Corp.
Bedford, MA

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ENVIRONMENTAL ASSESSMENT: SOURCE TEST AND EVALUATION REPORT - EXXON MINIPLANT PRESSURIZED FLUIDIZED-BED COMBUSTOR WITH SORBENT REGENERATION

Final Report

May 1981

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16. ABSTRACT The report gives results of a comprehensive emission sampling and analysis of the EPA-sponsored, Exxon Miniplant, pressurized, coal-fired, fluidized-bed combustor (PFBC) and sorbent regeneration system. Air pollutant emissions of seven trace elements exceeded emissions goals in the PFBC flue gas, indicating a need for further study. Air pollutant emissions of total organics were less than for comparable conventional combustion systems. Limited further analyses for specific polynuclear aromatic compounds indicated that emissions of one of these compounds exceeded its emissions goal. Laboratory-generated leachates from solid waste samples resulted in trace metal concentrations ~~well~~ below Federal hazardous waste criteria. Positive test results for mutagenicity and cytotoxicity screening tests on flue gas samples require further study.

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Fluidized Bed Processing	Regeneration	Stationary Sources		14G
	Sampling	Sorbent Regeneration	13H,07A	
Coal	Analyzing	Trace Elements	21D	
Combustion	Chemical Analysis	Environmental Assessment	21B	07D
Assessments	Leaching		14B	

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SECTION 1

SUMMARY OF EXXON MINIPLANT PFBC SOURCE TEST AND EVALUATION

INTRODUCTION

In May 1979 GCA/Technology Division conducted a detailed sampling program at the Exxon Miniplant pressurized fluidized-bed combustor (PFBC) operating with sorbent regeneration as part of the complete Environmental Assessment of fluidized-bed technology.*

Sampling and analysis was conducted at the Miniplant in accordance with the phased approach to environmental assessment of energy and industrial processes which has been developed by the U.S. Environmental Protection Agency through their Industrial Environmental Research Laboratory at Research Triangle Park, NC (IERL-RTP). The phased environmental assessment methodology is designed to permit comprehensive analysis of multimedia pollutants in industrial emission streams in a cost-effective manner. Three levels of chemical, physical, and biological testing are included in this program. Level 1 testing provides a screening process which serves to rank emission streams from a source by potential hazard to man or the environment, thus identifying streams for further, more intensive (Level 2) analysis. This Source Test and Evaluation Report presents the results of the Level 1 sampling and analysis program conducted by GCA at the Exxon Miniplant PFBC operating with sorbent regeneration.

A description of the Exxon Miniplant as it operated during the Level 1 sampling program, combustor and regenerator operating conditions, and stream flow rates may be found in Section 2. Details of sampling techniques and analytical methods employed to quantify inorganic and organic chemical species and biological activity of Exxon samples are in Sections 3 and 4, respectively. Sampling and analysis was conducted based on the procedures specified in the Level 1 Procedures Manual.[1] Any variation from Level 1 protocols are discussed.

SUMMARY OF TEST RESULTS

Data generated from Level 1 analyses of Exxon samples were of three general types: inorganic analysis relying upon spark source mass spectroscopy (SSMS), atomic absorption spectrometry (AA), or wet chemical techniques;

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*GCA Corporation, GCA/Technology Division, conducted the field measurement under U.S. Environmental Protection Agency Contract No. 68-02-2693; Exxon Research and Engineering operated the Miniplant and supported the field program under U.S. Environmental Protection Agency Contract No. 68-02-1312.

organic analysis using gravimetry; liquid chromatographic separation, infrared spectrophotometry; or low-resolution mass spectrometry (and onsite gas chromatography for gaseous streams); and bioassay results of specific health or ecological effects testing.

Inorganic Data

Table 1 presents a summary of inorganic elemental data for Exxon Miniplant samples. Data are from SSMS or AA for gaseous waste stream samples, solid stream samples and laboratory-generated distilled-water leachates. Measured concentrations were compared to their respective appropriate emission goals (DMEGs).

Data in Table 1 show seven elements exceeding emissions goals in combustor flue gas. Flagging of these elements is indicative of a potential area for Level 2 investigation. However, as discussed in Section 5, Level 2 efforts would have to be preceded by validation of the Level 1 SSMS results. Some elemental concentrations, especially Cr, Ni, and Fe may have been high because of contamination from the stainless steel of the sampling train. Although four elements exceed their DMEG in regenerator flue gas, further analyses of this stream are unlikely. Regenerator flue gas would be treated prior to venting to the atmosphere and thus does not represent a true emission stream.

Bulk solid waste steams from the Exxon Miniplant PFBC were chemically evaluated in two ways. Solid samples were analyzed for trace elements by SSMS (AA for Hg and Sb) and compared to land DMEG emission goals. In addition to this, distilled water leachates were prepared, analyzed in a similar manner and the results compared to water DMEGs.

As seen in Table 1, numerous, albeit similar, trace elements exceeded their respective land DMEG values in all solids collected by the various control devices employed at Exxon. Only four elements exceeded one or both land DMEGs for Spent Combustor Bed Material. When laboratory leachates of these bulk solid materials were prepared and analyzed, however, no element in any sample exceeded any discharge goal. In fact, most elemental concentrations in the leachates were more than two orders of magnitude below their goals.

These contradictory results make evaluation of solid waste streams difficutl. In each case the discharge goals employed for comparison with elemental concentrations in the sample are meant to provide a means of assessing a potential health or environmental hazard due to worst case leaching of a bulk solid residue relegated to a landfill or other disposal area. We have assumed that analysis of the laboratory-generated leachates and comparison with water DMEGs provides a truer measure of the potential hazards associated with the leaching potential of Exxon bulk solids than does comparison of solids data with land DMEGs. Based on these leachate data, leaching of potentially toxic species from disposed solid waste streams at Exxon would not appear to be a problem. Solid waste streams would, therefore, be at a lower priority for subsequent Level 2 analysis than would flue gas particles.

TABLE 1. SUMMARY OF INORGANIC TRACE ELEMENT DATA FOR EXXON MINIPLANT SAMPLES

Stream description	Number of chemical species >DMEG	Identity of chemical species >DMEG
Gaseous waste streams[a]		
Regenerator flue gas	4	V, Cr, Ni, Rh
Combustor flue gas[b]	7	P, Ca, V, Cr, Fe, Ni, As
Solid streams[c]		
Regenerator cyclone solids	14	Be, Al, P, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, As, Cd
ESP hopper ash	16	Al, P, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, As, Se, Cd, Ba, Pb
Second combustor cyclone solids	14	Al, P, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, As, Cd, Pb
Third combustor cyclone solids	15	Al, P, Ca, Ti, V, Cr, Mn, Fe, Ni. Cu, Zn, As, Se, Cd, Pb
Spent combustion bed material	4	Ca, P, Fe, Ni
Laboratory-generated, distilled-water leachates[d]		
Regenerator cyclone solids	0	
Second combustor cyclone solids	0	
Third combustor cyclone solids	0	
Spent combustion bed material	0	
Coal feed	0	
Sorbent feed	0	

[a] Air DMEGs used for comparison.

[b] Results represent emissions for the total flue gas stream. Dilution air was not analyzed and is assumed not to contribute to the totals of inorganics analyzed.

[c] Land DMEGs used for comparison.

[d] Water DMEGs used for comparison.

Organic Data

Samples from the Exxon Miniplant generally contained low levels of organic compounds compared to DMEGs and Level 1 organic analysis criteria.

The SASS-train organic module (XAD-2 resin adsorbent extracted with CH_2Cl_2) from the regenerator flue gas streams and the diluted combustor flue gas stream were the only samples analyzed that contained sufficient organic material to require liquid chromatographic separation. Because organic concentrations were so low the infrared spectrometry and low resolution mass spectrometry analyses provided only general results that were of limited use. The complete organic data are presented in Appendix A.

Samples analyzed from the Exxon Miniplant generally contained such low levels of organic compounds that inclusion of these data into the SAM/1A format was not practicable. Therefore, SAM/1A was only used to flag those inorganic trace elements which exceeded their respective DMEG, as noted above. Organic data were interpreted in the following manner:

a. Initial Level 1 organic data were compiled. These data included totals for volatile species (TCO-Total Chromatographable Organics), nonvolatile species (GRAV-Gravimetric), and onsite GC spectra where applicable.

b. A survey was made of all DMEG values that have been adopted for organic compounds or classes of compounds (586 to date).

c. The assumption was made that the total weight of organics present in the sample analyzed was representative of one compound, as a worst case, and all species whose DMEG was lower than this total were listed. This exercise resulted (for some samples) in a list of compounds of "potential concern." In other samples, this exercise resulted in elimination of organic compounds as an area of concern for future investigation.

d. These compounds were then reviewed based on knowledge of process chemistry, operating conditions, and the available Level 1 bioassay results. This review enabled elimination of some species which could not possibly be present in these FBC emission streams.

e. A final list (on a stream-by-stream basis) of organic compounds of potential concern was compiled.

Organic compounds of concern in Exxon emission streams appear to be limited to polynuclear aromatic (PNA) species which might be present in SASS-train samples (particles and XAD) obtained from combustor and regenerator flue gases.

Bioassay Data

Results of testing Exxon Miniplant samples in the Level 1 bioassay screen are summarized in Table 2. Results are listed based on qualitative Level 1

TABLE 2. SUMMARY OF BIOASSAY RESULTS OF EXXON PFBC SAMPLES

Sample description	Health effects tests			Ecological effect tests		
	Ames mutagenicity[a]	RAM cytotoxicity	CHO cytotoxicity	Fish (96-hour LC_{50})	Daphnids (48-hour LC_{50})	Algae (EC_{50})
Scrubber slurry	-	N[b]	-	High	High	Moderate
XAD blank	-	N	-	N	N	N
Combustor flue gas - XAD	+	N	-	N	N	N
Regenerator flue gas - XAD	+	N	High	N	N	N
Fine SASS particulate	+	N	N	N	N	N
Coarse SASS particulate	+	N	N	N	N	N
SASS filter-control	-	N	N	N	N	N
ESP hopper ash	+	Low	N	N	N	N
Regenerator cyclone	-	Low	N	High	High	High
Combustor bed material	-	Low	N	High	High	High
2° Cyclone catch	-	Low	N	High	High	High
3° Cyclone catch	-	Moderate	N	Low	Moderate	High

[a] + = positive or negative mutagenic response; no detectable toxicity.

[b] N indicates this assay not run for the indicated sample.

bioassay response criteria, except Ames results which are simply listed as positive/negative.

Five samples were positive (mutagenic) in the Ames test. Similar positive results have been observed in testing samples from conventional combustion systems as well as samples of ambient air (airborne particulate matter). With the exception of the third cyclone catch, all streams exhibited low toxicity to RAM cells. Regenerator flue gas XAD-extract was the only sample toxic to CHO cells. Regenerator cyclone catch leachate, spent combustion bed material leachate, and second cyclone catch leachate all exhibited high toxicity in all ecological effects tests. Third cyclone catch leachate was variably toxic in these tests depending on the organism exposed. Positive results in ecological biotesting is probably a result of high pH.

The resulting three sets of data from Level 1 analysis for each tested stream from the Exxon Miniplant PFBC were compared. Inorganic species which were flagged by SAM/1A as exceeding one of their emission goals, organic species of potential concern possibly present in a sample (as determined above), and the response of a sample in the Level 1 battery of biological tests were all considered in making final evaluation of which streams should first receive Level 2 analysis.

LEVEL 2 CHEMICAL INVESTIGATION OF EXXON MINIPLANT SAMPLES

Limited Level 2 chemical analysis was performed on selected Exxon stream samples. Samples selected for Level 2 analysis were those suspected of containing polynuclear aromatic (PNA) species based on LRMS data (see Appendix A) or those samples which had demonstrated positive mutagenic response in the Ames test. Even though Ames test results indicated that PNA species could not be solely responsible for the observed mutagenic response, because of the lack of activity in the presence of S-9 mix, quantification of PNA species in Exxon samples still provides valuable compound-specific information which will aid in selection of appropriate fractionation schemes for future analysis.

Our initial Level 2 analysis involved screening of those Exxon samples selected using high performance liquid chromatography (HPLC) with fluorescence detection. Analytical procedures and instrumental operating conditions have been described in Section 4.

Data indicate that XAD extract from both combustor and regenerator flue gas streams contain levels of 1,2,5,6-dibenzanthracene in excess of air DMEG levels and thus warrant further investigation.

RADIOASSAY OF EXXON MINIPLANT SAMPLES

Multimedia samples collected during the May 1979 Level 1 sampling program at the Exxon Miniplant were analyzed for selected radioisotopes. Radioisotope emissions data from fluidized-bed combustion are required by the EPA-Office of Radiation Programs to evaluate the need, if any, for emissions limitations or other standards or criteria as instructed by the Clean Air Act Amendments. Also, these data serve as an initial effort toward incorporation of radioactivity (as an environmental pollutant) into the environmental assessment methodology developed by the EPA Office of Research and Development through IERL-RTP.

In all, seven solid samples were analyzed. Coal and sorbent feedstocks were analyzed for isotopic uranium (^{234}U, ^{235}U, ^{238}U) and isotopic thorium (^{228}Th, ^{230}Th). ESP hopper ash was not available in sufficient quantity to permit analysis for thorium isotopes but was analyzed for isotopic uranium, ^{226}Ra, ^{228}Ac, ^{210}Pb, and ^{210}Po. Regenerator cyclone solids, solids captured by second and third combustor cyclones and spent bed material were assayed for all nine isotopes.

Data indicate that most of the radioisotopes leave the system as part of the second and third combustor cyclone catches. Radioisotopes escaping the plant in the flue gases at Exxon or in a commercial FBC facility would probably be 1 to 20 percent of that measured in the ESP hopper catch. Complete data are in Section 7.

SECTION 2

PLANT DESCRIPTION

INTRODUCTION

The EPA-sponsored Exxon Miniplant is a pressurized fluidized-bed combustor (PFBC) and sorbent regeneration system with a coal firing capacity of 1.8 MW (6.3×10^6 Btu/hr). Exxon operated the Miniplant from early 1974 to the summer of 1979, when the program ended. During the several thousand operating hours, extensive investigations of sulfur capture, NO_x emissions and control, high pressure/high temperature particulate control, combustion efficiencies and many other aspects of fluidized-bed combustion were completed.[2,3,4] Sorbent regeneration was demonstrated in 1975 and an experimental program including sorbent regeneration was conducted during the first half of 1979.

PROCESS DESCRIPTION

A schematic diagram of the Exxon Miniplant as it operated during the Level 1 sampling program is presented in Figure 1. Individual components of the process are briefly described below.

Solids Feeding

Coal and sorbent are injected pneumatically through a single port 28 cm (11 in.) above the water-cooled fluidizing grid. The tip of the probe includes ten 0.79 mm (0.03 in.) diameter holes which surround the solids feed opening. They are used to continuously inject an annular stream of sonic-velocity air to assist penetration of the solids feed into the fluidized-bed and to protect the feed nozzle from blockage with bed solids. The flow of solids into the combustor is controlled to maintain constant temperature in the combustor.

Fluidized-Bed Combustion

The combustor is a 9.75 m (32 ft) high refractory-lined vessel with an inside diameter of 33 cm (13 in.). Heat of combustion is removed by water-cooled tubes located in the fluidized-bed. Coal feed rates of 230 kg/hr (500 lb/hr) and expanded bed heights of 6.1 m (20 ft) are possible but the unit usually operates at about half these values. The combustor fluidizing grid consists of a 1.3 cm (0.5 in.) thick x 69 cm (27 in.) diameter stainless steel plate containing 776 equally spaced holes of 0.16 cm (0.063 in.) diameter within a 31.8 cm (12.5 in.) circle. The unit is water-cooled with both the cooling water temperature and metal temperature continuously measured.

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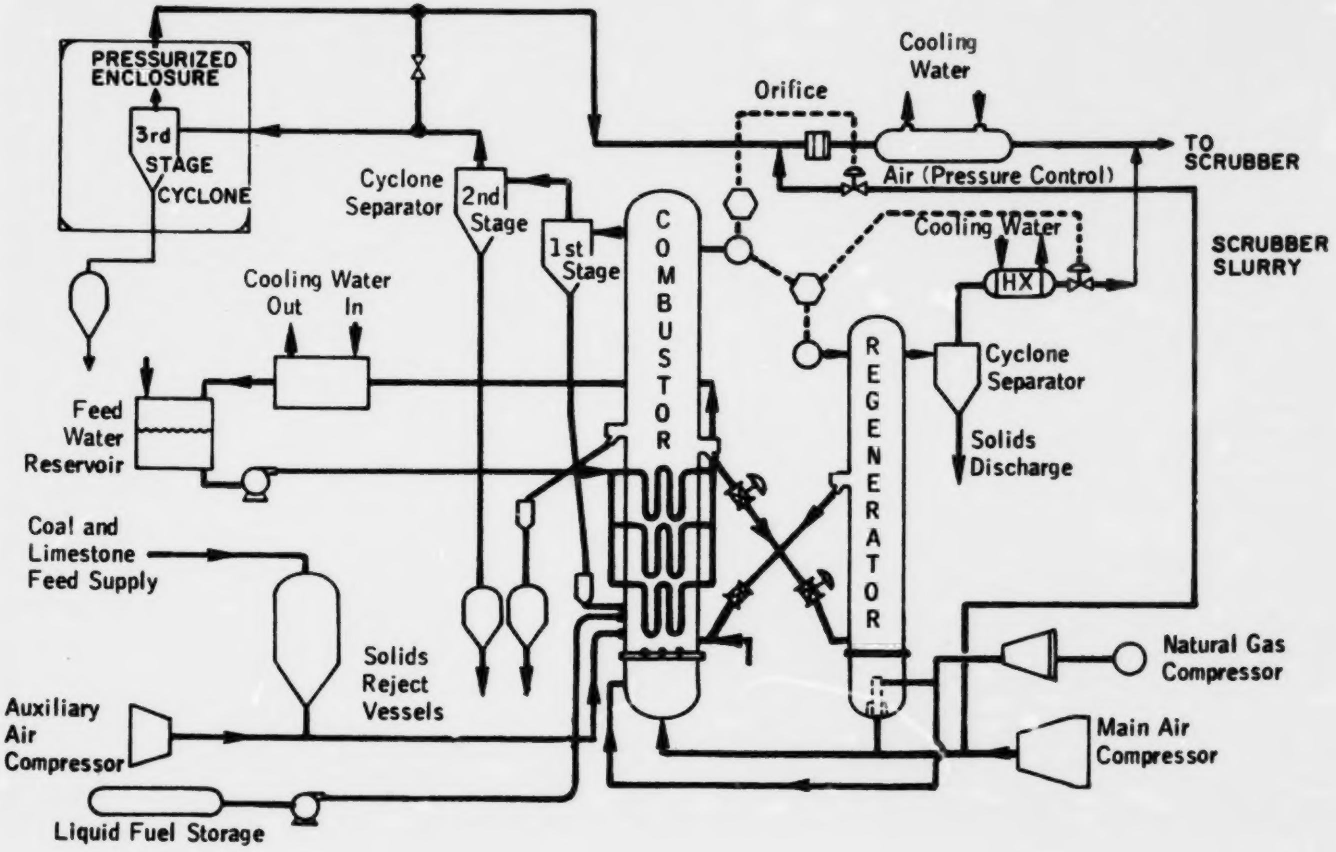
PRESSURIZED ENCLOSURE
3rd STAGE CYCLONE
Cyclone Separator
2nd Stage
1st Stage
Cooling Water
Out
In
Feed Water Reservoir
Coal and Limestone Feed Supply
Solids Reject Vessels
Auxiliary Air Compressor
Liquid Fuel Storage
COMBUSTOR
Orifice
Cooling Water
TO SCRUBBER
Air (Pressure Control)
Cooling Water
HX
SCRUBBER SLURRY
REGENERATOR
Cyclone Separator
Solids Discharge
Natural Gas Compressor
Main Air Compressor

Figure 1. Schematic of the Exxon Miniplant PFBC as it operated during the Level 1 Environmental Assessment.

Solids rejection from the combustor is accomplished through a port located 230 cm (90 in.) above the fluidizing grid. From this port the solids flow by gravity through a steel pipe into a pulse pot. The solids are then pneumatically transported by controlled nitrogen pulses to a pressurized lockhopper from which they are periodically dumped into metal drums. A similar system, not including a pressurized lockhopper, is used to transfer solids to the regenerator.

Combustion and fluidizing air are provided by a main air compressor (shown in Figure 1) with a capacity of 40 Nm^3/min at 1,030 kPa (1,400 cfm at 150 psig). Pressure in the combustor is controlled by maintaining a specified gas flow across an appropriately sized ceramic-coated orifice. The specified gas flow is maintained by dilution of the flue gases with high pressure air as shown in the top of Figure 1.

Sorbent Regeneration

The sorbent regenerator consists of a refractory-lined vessel with an inside diameter of 22 cm (8.5 in.) and an overall height of 6.7 m (22 ft). Operating temperatures as high as 1100°C (2000°F) and pressure up to 1000 kPa (10 atm) can be achieved in the regenerator. Typical superficial velocity is 0.6 m/s (2 ft/s) with an expanded bed height of 2.3 m (7.5 ft).

The regeneration process is based on the one step reductive decomposition of $CaSO_4$ by the following reaction:

$$CaSO_4 + \begin{Bmatrix} H_2 \\ CO \end{Bmatrix} \rightleftharpoons CaO + \begin{Bmatrix} H_2O \\ CO_2 \end{Bmatrix} + SO_2 \tag{1}$$

An undesirable competing reaction involving the formation of CaS also occurs:

$$CaSO_4 + 4 \begin{Bmatrix} H_2 \\ CO \end{Bmatrix} \rightleftharpoons CaS + 4 \begin{Bmatrix} H_2O \\ CO_2 \end{Bmatrix} \tag{2}$$

Therefore, an oxidizing zone is provided in the regeneration vessel to convert CaS to $CaSO_4$:

$$CaS + 2O_2 \rightleftharpoons CaSO_4 \tag{3}$$

At the Miniplant, natural gas is burned in the plenum below the fluidizing grid to achieve the reaction temperature. Additional fuel is injected directly into the bed just above the fluidizing grid to create a reducing zone in which reaction No. 1 occurs. Supplementary air is injected into the fluidized-bed to create an oxidizing zone to convert CaS to $CaSO_4$ via reaction No. 3.

Flue Gas and Flue Gas Particulate Handling

Combustor Flue Gases--

Flue gas and entrained solids (fly ash and sorbent) exit the top of the combustor and enter a three-stage cyclone system. Solids separated by the first-stage cyclone drop through a steel dipleg and enter a pulse pot from which they are pneumatically conveyed back to the combustor (100 percent reinjected). Solids (primarily fly ash) escaping the primary cyclone enter more efficient second and third-stage cyclones where finer sizes of solids are captured. The collected solids from these cyclones pass through separate diplegs and enter pressurized lockhoppers from which solids are periodically dumped into metal drums.

Typical dust concentration in the flue gases leaving the first-stage cyclone is 8 to 12 g/Nm^3 with a mass median diameter of 20 to 25 µm. The second-stage cyclone collects the above particles with an efficiency of 90 to 95 percent, reducing the particulate concentration to 0.4 to 1.2 g/Nm^3 with a mass median diameter of 3 to 5 µm. The third-stage cyclone operates at 85 to 94 percent efficiency. The final flue gases generally contain 0.03 to 0.15 g/Nm^3 of particulates with a mass median diameter of 1 to 3 µm.[5]

After leaving the third-stage cyclone, the flue gas passes through a 10.2 cm (4 in.) inside-diameter steel pipe and is expanded through a converging nozzle. Approximately 0.6 m upstream of the nozzle, a secondary source of high pressure air is metered through a ball valve equipped with a pneumatic actuator and positioner. By superimposing this secondary flow of air on the primary flow of flue gas through the nozzle, control of gas pressure in the combustor is maintained at the desired level which has been typically 950 kPa (9.5 atm).

During the Level 1 test series, the EPA mobile electrostatic precipitator was used to remove additional particulate from the cooled, depressurized flue gases. This experiment was being conducted because the final particulate concentration of 0.03 to 0.15 g/Nm^3 might be adequate for process performance but emissions would need to be limited to 13 ng/J (equivalent to about 0.035 g/Nm^3) to meet Federal New Source Performance Standards for utility boilers.

Regenerator Off Gas--

Hot flue gases from the regenerator pass through a cyclone to remove entrained particles. Next the gases are cooled from 930°C (1700°F) to about 200°C (390°F) in a water-cooled heat exchanger. Gases are depressurized as they pass through a control valve (as shown in the upper right hand corner of Figure 1) before entering a scrubber for final cleanup before venting to the atmosphere.

OPERATING CONDITIONS

Combustor and regenerator operating conditions during the EPA test program are presented in Table 3. Champion coal with a sulfur content of 1.7 percent and Grove limestone were used during the tests. It was necessary to feed significant quantities of fresh limestone to compensate for elutriation and to maintain the bed in the combustor. Because high sulfur coal was not available the resultant Ca/S ratio was 1.29, much higher than desirable for commercial regenerative operation. Also, the pressure in the system was 700 kPa (7 atm) instead of the normal 950 kPa (9.5 atm) in order to achieve adequate fluidizing velocities in the regenerator. The net result was lower than design SO_2 content in the regenerator flue gases. Because the pressure was 30 percent lower than past experimental runs, coal feed rate was reduced to maintain the desired excess air at the specified fluidizing velocity. Stream flow rates are summarized in Tables 4 and 5.

TABLE 3. SUMMARY OF EXXON MINIPLANT PFBC OPERATING CONDITIONS

Parameter	Combustor	Regenerator
Length of run (hours)	99	81
Pressure (kPa)	700	705
Average bed temperature (°C)	894	1010-1031 (oxidizing-reducing)
Expanded bed height (m)	3.1	1.9
Superficial velocity (m/s)	1.5	0.6-0.8 (oxidizing-reducing)
Ca/S molar ratio	1.29	-
Coal feed rate (kg/hr)	77	-
Coal type (percent S)	Champion (1.7)	-
Coal higher heating value (kJ/kg)	31,400	-
Coal size (mesh)	< 16	-
Sorbent feed rate (kg/hr)	5.4	-
Sorbent type	Grove limestone	Grove limestone
Sorbent size (mesh)	8 x 25	-
Excess air (percent)	46	-
Oxygen content of flue gas (percent)	4.1	0.3

TABLE 4. GASEOUS STREAM FLOW RATES AND PARTICULATE LOADINGS DURING LEVEL 1 TESTING

Gaseous streams	Flow (m^3/s)	Particulate loading (mg/m^3)
Combustor flue gas before dilution	0.2333	178[a] 47[b] 100[c]
After dilution	0.3817	109[a] 29[b] 61[c]
Regenerator flue gas	0.0450	7[c]
Dilution air	0.1478	1[c]

[a] Exxon measured.

[b] GCA calculated tests 1 and 2

[c] GCA measured tests 1 and 2

TABLE 5. SOLID STREAM FLOW RATES DURING LEVEL 1 TESTING

Solid streams	Flow (g/s)
Regenerator cyclone solids	0.2394
Spent combustion bed	0[a]
Second cyclone solids	1.4238
Third cyclone solids	0.3780
Coal feed rate	21.4
Sorbent feed rate[b]	1.5

[a] All spent bed solids are regenerated.

[b] GCA calculated.

SECTION 3

SAMPLING TECHNIQUES

INTRODUCTION

Eleven streams were sampled for chemical and biological analysis at the Exxon Miniplant PFBC. These sampling points are illustrated in Figure 2 and the streams sampled are described in Table 6. The Level 1 measurement program included sampling of four gaseous streams, six solid streams, and one liquid stream. Sampling procedures and handling of samples following the test period were basically those specified in the Level 1 Procedures Manual.[1] Variation from Level 1 techniques due to unusual stream characteristics is discussed.

SAMPLING METHODOLOGY

Solid Stream Sample Collection

A total of six solid streams was sampled at the Miniplant for this program (samples 5 through 10 in Table 6). These included two feed streams and four waste streams. Samples for chemical and most biological analyses were collected by Exxon personnel every 2 hours during the flue gas sampling. All solid samples were received by a designated GCA field team member and then split for organic and inorganic analysis. The individual organic and inorganic samples were each composited during the test run to provide a representative sample of each solid stream. At the conclusion of each test run the composited samples were labeled and inventoried for shipment to the home laboratory.

Bulk samples for generation of leachates and subsequent ecological testing were collected from several hours before to several hours after the flue gas sampling runs. These samples were stored in polyethylene-lined 55-gallon drums.

Gaseous Stream Sample Collection

Sampling and species quantified for the four gaseous streams at Exxon are summarized in Table 7. In order to provide samples of the combustor flue gas and the regenerator offgas for Level 1 Environmental Assessment analysis, the Source Assessment Sampling System (SASS) was used to collect samples of the particulate and gaseous components of each indicated gaseous stream.

The SASS train (pictured in Figure 3) collects particles in a series of three cyclones with nominal cut points of 10 μm, 3 μm, and 1 μm. A 150 mm filter collects the particles which are less than 1 μm in diameter. The volatile organics are captured by 150 g of XAD-2 resin in a temperature-controlled

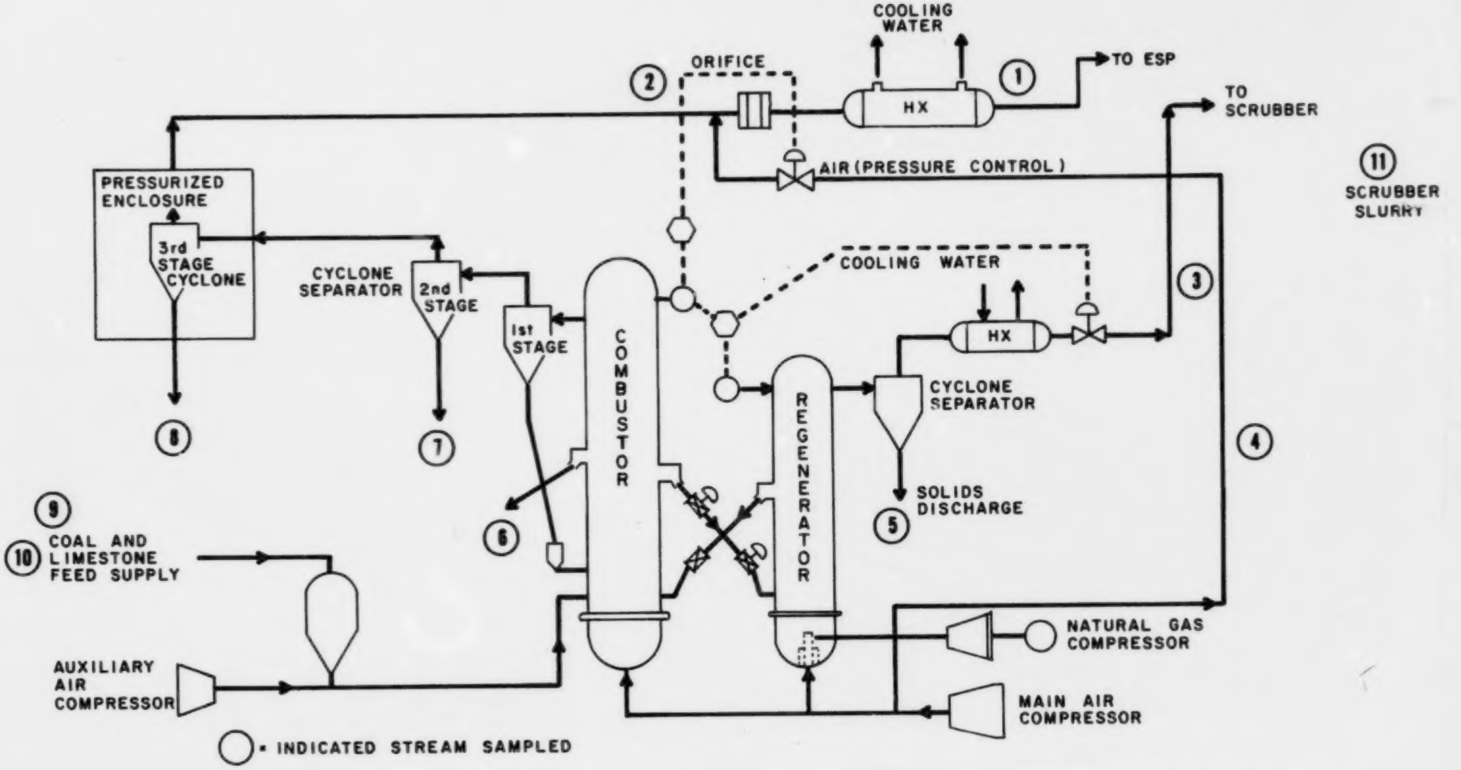
COOLING WATER
ORIFICE
②
HX
①
TO ESP
TO SCRUBBER
⑪ SCRUBBER SLURRY
AIR (PRESSURE CONTROL)
PRESSURIZED ENCLOSURE
3rd STAGE CYCLONE
CYCLONE SEPARATOR
2nd STAGE
1st STAGE
COMBUSTOR
COOLING WATER
HX
③
REGENERATOR
CYCLONE SEPARATOR
SOLIDS DISCHARGE
⑤
④
⑧
⑦
⑥
⑨
⑩ COAL AND LIMESTONE FEED SUPPLY
AUXILIARY AIR COMPRESSOR
NATURAL GAS COMPRESSOR
MAIN AIR COMPRESSOR
○ = INDICATED STREAM SAMPLED

Figure 2. Exxon Miniplant — Level 1 sampling points.

TABLE 6. SUMMARY OF STREAM SAMPLE CHARACTERISTICS

Sample point identification No.	Stream description	Physical state	Collected by	Important characteristics
1	Diluted combustor flue gas (cooled) (ESP hopper catch)	Gas and solid	GCA	Fly ash entrained in combustion gases, particle concentration about 0.15 g/Nm^3, mass median particle size below 5 μm. Temperature 175^{o}C (350^{o}F), pressure 136 kPa (5 psig).
2	Undiluted combustor flue gas (hot)	Gas	GCA	Similar to (1) but temperature is 750^{o}C (1500^{o}F) and pressure is 700 kPa (7 atm).
3	Regenerator flue gas (cooled)	Gas	GCA	Sorbent particles entrained in off gases, low particle loading, temperature and pressure similar to (1).
4	High pressure dilution air	Gas	GCA	Compressor output containing organic residue from lubricating oil, pressure is 700 kPa (7 atm).
5	Solids from regenerator cyclone	Solid	Exxon	No special characteristics.
6	Spent combustion bed solids	Solid	Exxon	Solids stream containing spent sorbent and some bottom ash, discharge temperature approximately 900°C (1700°F).
7	Solids from second combustor cyclone	Solid	Exxon	Stream contains fly ash, particles of mass median diameter approximately 17 μm, temperature approximately 150 to 300°C (300 to 600°F).
8	Solids from third combustor cyclone	Solid	Exxon	Stream contains fly ash, particles of mass median diameter approximately 4 μm, temperature approximately 150 to 300°C (300 to 600°F).
9	Cool feed	Solid	Exxon	No special characteristics.
10	Sorbent feed	Solid	Exxon	No special characteristics.
11	Scrubber slurry	Liquid	Exxon	Liquid stream containing fly ash from stream 3 and condensed compounds, also ammonia, temperature 25 to 40°C (70 to 100°F).

TABLE 7. SUMMARY OF SAMPLING OF EXXON MINIPLANT GASEOUS STREAMS

Species quantified	Diluted combustor flue gas	Undiluted combustor flue gas	Regenerator flue gas	Compressed air	Sampling technique
Sulfur					
$SO_4/SO_3/SO_2$	-	✓	-	-	Goksoyr-Ross Train
SO_4/SO_3	✓	-	✓	-	SASS Train
SO_2	-	✓	✓	-	Exxon continuous monitor
H_2S	-	✓	✓	-	Exxon analysis of grab sample[a]
COS	-	✓	✓	-	Exxon analysis of grab sample[a]
CS_2	-	✓	✓	-	Exxon analysis of grab sample[a]
R-SH	-	✓	✓	-	Exxon analysis of grab sample[a]
Nitrogen					
NO_X	✓	✓	-	-	Exxon continuous monitor
NH_3	-	✓	✓	-	Modified EPA Method 5
HCN	-	✓	✓	-	Modified EPA Method 5
Fixed Gases					
CO_2	✓	✓	✓	-	Integrated Bag
O_2	✓	✓	✓	-	Integrated Bag
N_2	✓	✓	✓	-	Integrated Bag
CO	✓	✓	✓	-	Integrated Bag
Particulates					
Total	✓	-	✓	-	SASS Train
Sizing	✓	-	✓	-	SASS Train
Inorganics					
Trace elements	✓	-	✓	-	SASS Train
Cl^-	-	✓	-	-	Goksoyr-Ross Train
Cl^-	✓	-	✓	-	SASS Train
F^-	-	✓	-	-	Goksoyr-Ross Train
F^-	✓	-	✓	-	SASS Train
$PO_4^{\equiv}$	✓	-	✓	-	SASS Train
Organics					
GC_1-GC_7 organics	✓	✓	✓	✓	Evacuated Glass
Volatile Organics	✓	✓	✓	✓[b]	SASS Train
Nonvolatile Organics	✓	✓	✓	✓[b]	SASS Train

[a] The sampling program had originally included onsite analysis of these sulfur species, however, instrument malfunction required that these data be supplied by Exxon.

[b] A small resin trip adapted to a glass EPA Method 5 sampling train was used to collect organics in the compressed air stream.

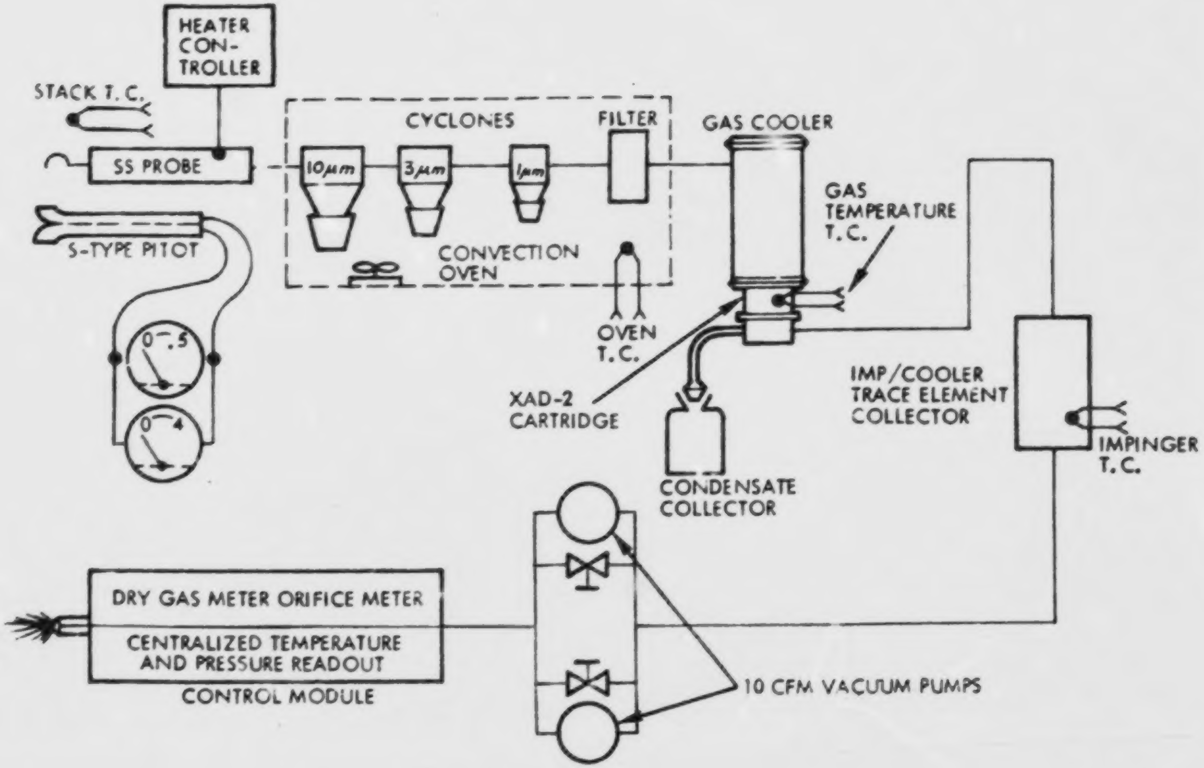
HEATER CON-TROLLER
STACK T.C.
SS PROBE
S-TYPE PITOT
0 .5
0 4
CYCLONES
10μm
3μm
1μm
FILTER
CONVECTION OVEN
OVEN T.C.
GAS COOLER
GAS TEMPERATURE T.C.
XAD-2 CARTRIDGE
CONDENSATE COLLECTOR
IMP/COOLER TRACE ELEMENT COLLECTOR
IMPINGER T.C.
DRY GAS METER ORIFICE METER
CENTRALIZED TEMPERATURE AND PRESSURE READOUT
CONTROL MODULE
10 CFM VACUUM PUMPS

Figure 3. Source Assessment Sampling System (SASS) Schematic.

trap. A series of impingers follows the resin trap to capture volatile metals. The total volume of gas sampled exceeded 30 Nm^3. Setup and performance of the SASS train followed Level 1 specifications (see reference 1).

The SASS train samples of the diluted combustion flue gas (stream 1) were obtained from a temporary duct leading to the mobile ESP. A standard SASS nozzle with an inside diameter of 1.9 cm (0.75 in.) was adapted to sample at a point of average velocity in the 26.7 cm (10.5 in.) diameter duct. The sampling location was ideal as it was more than eight duct diameters downstream and more than four duct diameters upstream from the nearest disturbances. Samples were collected on May 3 and 4, 1979.

Because organic contamination of the diluted combustor flue gas from the compressed air used for dilution was suspected, additional sampling was conducted before dilution (stream 2). The high temperature and pressure of the flue gases at this point did not permit the direct use of the SASS train. Instead the flue gases were sampled at point 2a in the sample treatment system shown in Figure 4. The SASS train cyclone, filter, and oven were not used at this sampling location because the Balston filter in the sample treatment system had already collected the particulates. The Balston filter operated at 260° (500°F). A SASS train organic module was used to collect volatile and nonvolatile organic species. Sampling was accomplished by connecting a flexible stainless steel line to the existing metering valve. Two test runs were conducted; one on May 2, 1979, and one on May 3, 1979. Sample volumes were 31 to 34 Nm^3.

The regenerator flue gases were also sampled with the SASS train. A straight, 0.696 cm (0.275 in.) inside-diameter stainless steel tube connected directly to the first SASS cyclone was used as the sampling probe. A nozzle was not needed because the probe was operated in the same direction as the flue gas flow by inserting it through an elbow in the piping. Sampling was conducted approximately at isokinetic conditions in the center of the 6.4 cm (2.5 in.) inside-diameter pipe transporting the regenerator flue gases. Sampling was conducted on May 2 and 3, 1979.

A small resin trap (see Figure 5) containing 25g of clean XAD-2 was used to collect organics in the dilution air. For sample collection the resin trap was adapted to a glass EPA Method 5 sampling train. The sampling train was attached to an existing tap on the compressed air supply line. A metering valve was used to control the sample flow rate and reduce the pressure to acceptable levels. Two sample runs of 220-minute duration were conducted; one on May 2, 1979, and one on May 3, 1979. Sample volumes were 5 to 5.2 Nm^3. The samples were recovered by transferring the XAD-2 to an amber glass jar and then rinsing the resin trap with methylene chloride (distilled-in-glass grade). This sample was then shipped to the GCA laboratory for organic Level 1 analysis.

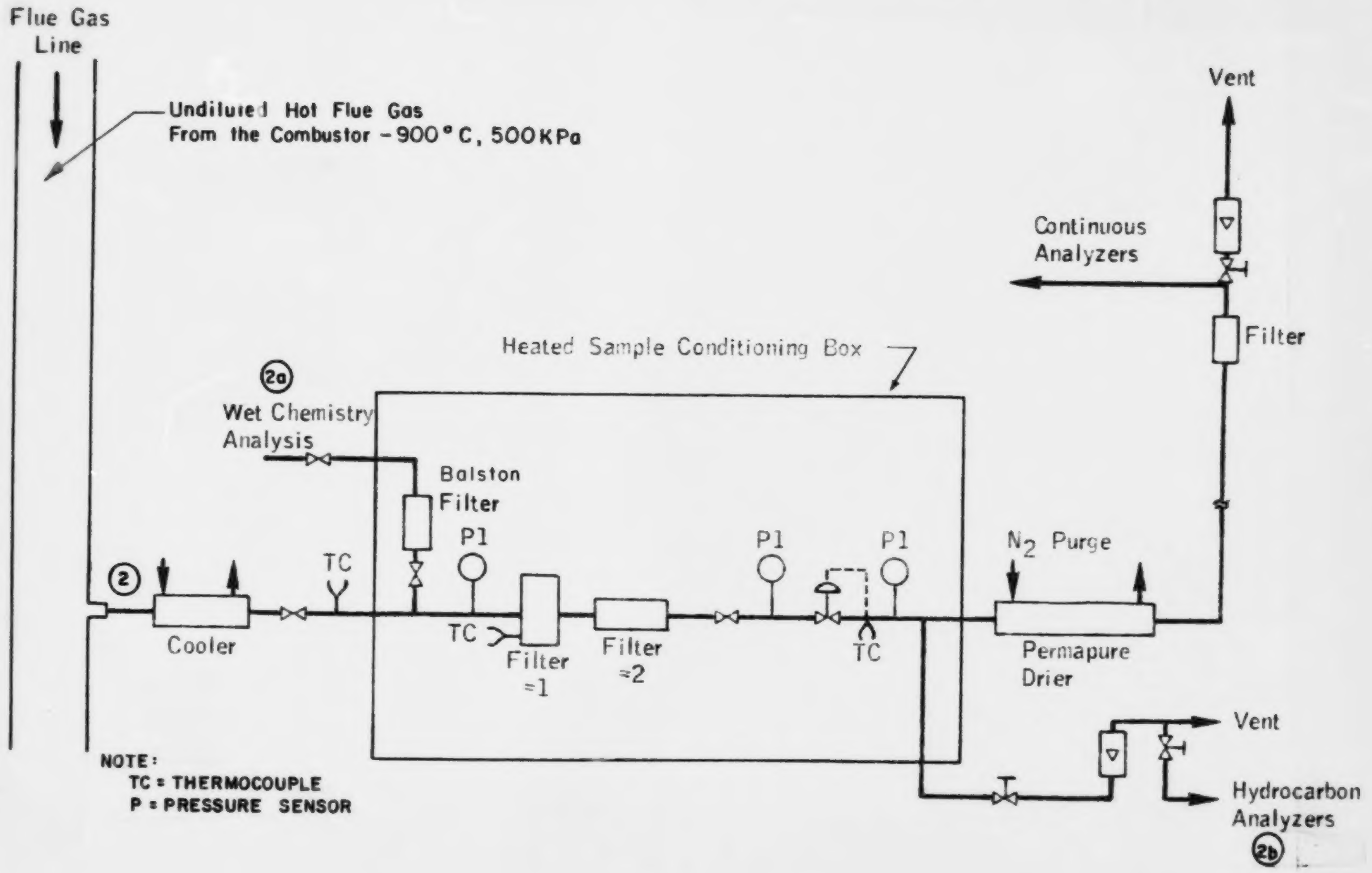
Flue Gas Line
Undiluted Hot Flue Gas From the Combustor -900°C, 500KPa
②
Cooler
TC
②a
Wet Chemistry Analysis
Balston Filter
P1
TC
Filter =1
Filter =2
P1
P1
TC
Heated Sample Conditioning Box
N_2 Purge
Permapure Drier
Filter
Continuous Analyzers
Vent
Vent
Hydrocarbon Analyzers
②b
NOTE:
TC = THERMOCOUPLE
P = PRESSURE SENSOR

Figure 4. Exxon's combustor flue gas sampling system.

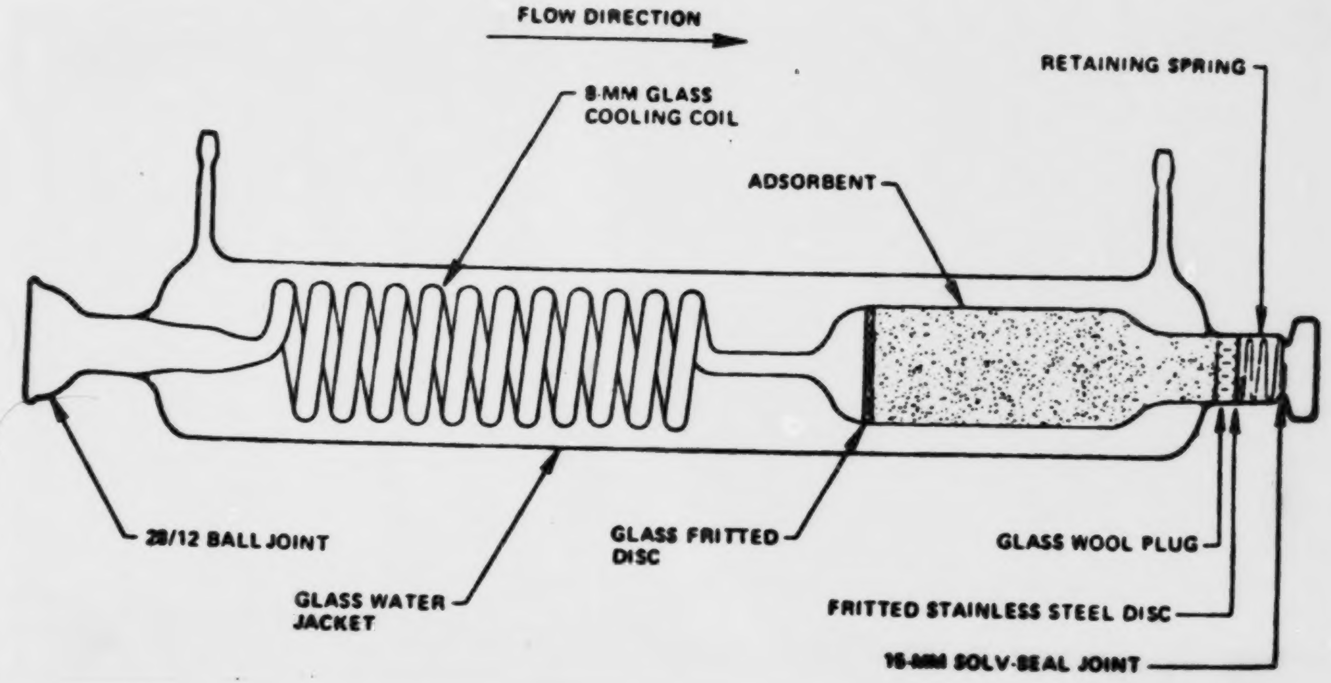
FLOW DIRECTION
8-MM GLASS COOLING COIL
ADSORBENT
RETAINING SPRING
28/12 BALL JOINT
GLASS WATER JACKET
GLASS FRITTED DISC
GLASS WOOL PLUG
FRITTED STAINLESS STEEL DISC
15-MM SOLV-SEAL JOINT

Figure 5. Resin trap for sampling organics in gas streams.

The undiluted combustor flue gas (stream 2) was sampled for sulfur species. Sampling was conducted on May 2 and 3 at sampling point 2a (see Figure 4). Samples were obtained by using a Goksoyr-Ross controlled condensation train (CCS). A schematic of the normal CCS is shown in Figure 6. For the purposes of this test program, the heated filter assembly was omitted because the sample treatment system contained a filter at 260° (500°F). The condenser coil was attached directly to the sampling tap with a control valve for flow rate adjustment.

The sampling rate was adjusted to maintain a flow of approximately 8 l/min through the sampling train. Temperature of the flue gas was reduced to the acid dewpoint at which $SO_3^=$ (H_2SO_4 vapor) condenses. The remaining gas was then passed through a cooled impinger system containing 3 percent H_2O_2 to trap $SO_2^=$ and then through an 8 percent Na_2CO_3 solution to trap HCl and HF. The samples were recovered by rinsing with deionized H_2O into Nalgene containers and shipped to the GCA laboratory for analysis.[6]

Gaseous components of the flue gas streams which were subject to volatilization or degradation were sampled and analyzed onsite. These species included the reduced nitrogen compounds HCN and NH_3, organic compounds with boiling points below 100°C (designated GC1-GC7), volatile sulfur compounds (SO_2, H_2S, COS, and CS_2) and fixed inorganic gases including CO_2, O_2, N_2 and CO.

A modified EPA Method 5 train was used to sample for reduced nitrogen compounds. The sampling train consisted of a standard Method 5 impinger box which was adapted to include a gas stream splitter from the sampling probe. Each of the split gas streams was drawn through an individual impinger train designed to trap ammonia in H_2SO_4 solution and cyanide in NaOH solution. Each sampled stream was individually metered to provide a measure of gas sampled. Samples were recovered by transferring the contents of each impinger to a Nalgene container and then rinsing each impinger and connections with deionized water.

Grab samples of the four gaseous streams for low-boiling (<100°C) organic analysis were obtained in evacuated 2-liter glass sampling bulbs. Inorganic fixed gas samples were obtained as integrated tedlar bag samples. Due to the pressure in the streams, gas samples were metered into the sample containers using a control valve and a bleed-off line. All samples were analyzed immediately after acquisition.

The sampling program was designed to provide onsite sampling and analysis of volatile sulfur compounds in the flue gas streams, but due to instrument malfunction, these analyses were not performed. Grab samples of the flue gas were analyzed by Exxon during each of the test runs and the results were provided to GCA for inclusion in this report.

Sample Collection - Liquid Stream

Exxon personnel provided a single sample of the scrubber slurry for field analysis and additional testing.

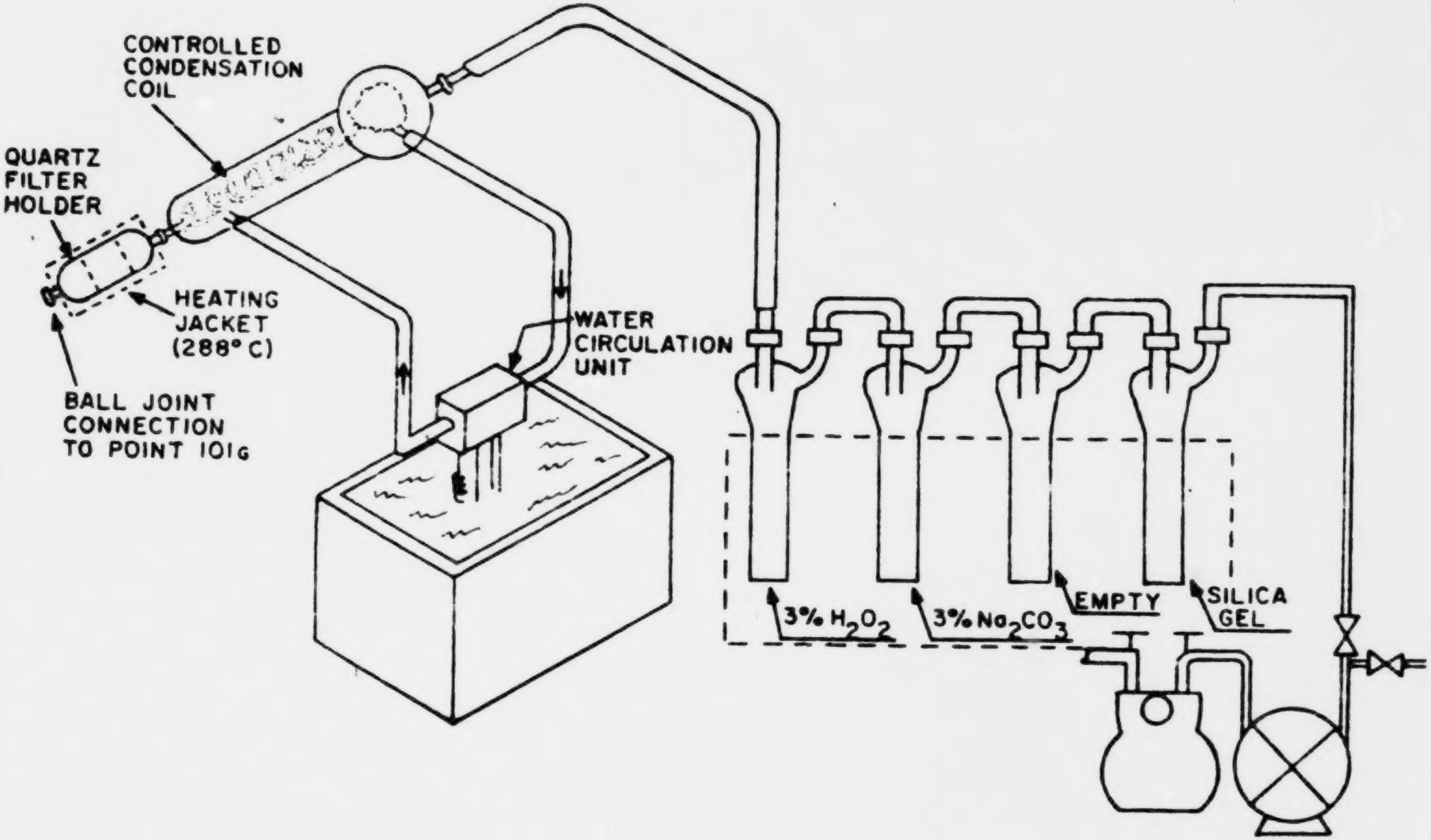
CONTROLLED CONDENSATION COIL
QUARTZ FILTER HOLDER
HEATING JACKET (288° C)
BALL JOINT CONNECTION TO POINT 101G
WATER CIRCULATION UNIT
3% H_2O_2
3% Na_2CO_3
EMPTY
SILICA GEL

Figure 6. Modified Goksoyr-Ross train.

SAMPLE HANDLING BEFORE ANALYSIS

All Level 1 quality control recommendations were followed in handling the samples following the sampling program and before chemical or biological testing. Samples from the individual sampling trains were quantitatively transferred into labeled containers for shipment. Table 8 lists these samples and their respective containers. Four-fifths of each condensate sample and 10 liters of scrubber slurry were methylene chloride-extracted. The remaining unextracted condensate and 1 liter of the slurry were acidified to $pH<2$. Two liters of untreated slurry were retained.

Bulk solids required no special preparation. Sufficient scrubber slurry, packed in ice, was delivered to Battelle Columbus Laboratories for biological testing.

TABLE 8. SAMPLE CONTAINMENT FOR SHIPMENT TO GCA LABORATORY

Sample	Containment
Particulate filters and blanks	Polystyrene Petri dishes
SASS cyclone catches	Tared Nalgene bottles
SASS probe and cyclone wash and blank (CH_2Cl_2/CH_3OH)	Amber glass bottles, caps with Teflon liners
SASS impinger solutions and blanks ($0.2M\ (NH_4)_2S_2O_8/0.02\ AgNO_3$)	Nalgene bottles
XAD-2 resins and blanks	Amber glass bottles
Organic module washes (CH_2Cl_2)	Amber glass bottles, caps with Teflon liners
Organic module washes and blank (HNO_3)	Nalgene bottles
Condensate extract (CH_2Cl_2)	Amber glass bottles
Neat and acidified condensate	Nalgene bottles
Impinger solutions from HCl and HF train	Polyethylene bottles
Impinger solution from HCN train	Polyethylene bottles
Impinger solution from NH_3 train	Glass bottles, caps with Teflon liners
Goksoyr-Ross front wash and blank	Glass bottles, caps with Teflon liners
Goksoyr-Ross coil rinse and blank	Nalgene bottles
Goksoyr-Ross impingers and blank	Nalgene bottles
Method 7 NO_x samples	Nalgene bottles
Bed discard solids, recycle or discard from first cyclone, second cyclone particulate discard, third cyclone particulate	Polyethylene bags
Scrubber slurry extract	Amber glass bottles, caps with Teflon liners
Neat and acidified scrubber slurry	Nalgene bottles

SECTION 4

ANALYTICAL TECHNIQUES

INTRODUCTION

This section presents an overview of the analytical techniques used to characterize the components of the process and emission streams sampled at the Exxon Miniplant as described in Section 3. Also described are sample preparation requirements preceding both inorganic and organic analytic methodologies. Techniques followed were generally those outlined in the Level 1 Procedures Manual.[1] Any variation from these specified procedures is discussed.

Onsite Analyses

Onsite analyses at Exxon were limited to analysis of grab samples obtained from the four gaseous emission streams. Some data were provided by Exxon personnel. Onsite analyses are summarized in Table 9. The chromatographic/wet chemical techniques used to quantify $SO_4/SO_3/SO_2$ species in the streams indicated in Table 9 are described in Inorganic Analytical Methods. Data provided by Exxon analyses or Exxon continuous monitor are presented in Section 5. Specific samples of nitrogen species were analyzed using the Nissler colorimetric method for NH_3 and the pyridine-pyrazolone colorimetric method for CN^-. NO_x data were provided by Exxon continuous monitor.

Fixed Gas Analyses

The fixed inorganic gases CO_2, O_2, and CO were analyzed by gas chromatography using a thermal conductivity detector (TCD). Operating parameters of the GC/TCD were:

• Column:	2 ft Chromosorb 102 - 4 ft 13X Molecular Sieve
• Detector:	Thermal conductivity
• Conditions:	$40^{\circ}C$ isothermal

The detection sensitivity by GC is 100 ppm. For levels of CO, MSA-Kitigawa detector tubes were used. These tubes have a sensitivity of 1 ppm.

Organic Analyses

Grab samples were analyzed for volatile (GC1-GC7) organics using a gas chromatograph with flame ionization detector. Operating conditions for these analyses were:

TABLE 9. ONSITE ANALYSIS OF GASEOUS EMISSION STREAMS AT EXXON

Species analyzed	Diluted combustor flue gas	Undiluted combustor flue gas	Regenerator flue gas	Compressed dilution air	Analytical technique	Detection limit
Sulfur						
$SO_4/SO_3/SO_2$	-	X	-	-	IC/WC	1 ppb
SO_4/SO_3	X	-	X	-	IC/WC	1 ppb
SO_2	-	X	X	-	Exxon continuous monitor	-
H_2S	-	X	X	-	Exxon analyses[a]	-
COS	X	X	X	-	Exxon analyses[a]	-
CS_2	X	X	X	-	Exxon analyses[a]	-
Nitrogen						
NO_x	X	X	X	-	Exxon continuous monitor	-
NH_3	X	X	X	-	WC	1 ppm
CN^-	X	X	X	-	WC	1 ppm
Fixed Gases						
CO	X	X	X	-	GC/TCD	100 ppm
CO	X	X	X	-	MSA-Kitigawa tube	1 ppm
CO_2	X	X	X	-	GC/TCD	100 ppm
O_2	X	X	X	-	GC/TCD	100 ppm
Organics						
GC1-GC7 volatile	X	X	X	X	GC/FID	0.1 ppm

[a] The sampling program originally included provision for analysis of these species. Instrument malfunction resulted in data being supplied to GCA by Exxon personnel.

Key:

X - indicates that stream was sampled and analyzed as indicated.
- - indicates that measurement was not made.
GC - gas chromatography.
TCD - thermal conductivity detector.
FID - flame ionization detector.
IC - ion chromatography.
WC - wet chemistry.

- Column:	10 ft x 1/8 in. 15 percent Squalene on Chromosorb PAW, 80/100 mesh
- Detector:	Flame ionization
- Conditions:	Helium carrier at 20 ml/min, 57°C isothermal

Results of all these analyses are presented in Section 5.

INORGANIC ANALYSIS PROCEDURES

Introduction

Inorganic species measurements were conducted in accordance with Level 1 environmental assessment procedures.[1] (See Figure 7). Spark Source Mass Spectrometry (SSMS) and Atomic Absorption (AA) techniques were combined to conduct a survey of many trace elements in appropriate Exxon sample streams. Refer to Table 10 for a complete listing of sample types and analytical techniques employed on each.

Spark Source Mass Spectrometry provided simultaneous screening for approximately 60 trace elements with little variability in individual detection limits. Atomic absorption techniques were used to complement SSMS for the analysis of mercury and antimony in appropriate samples.

Additional measurements were conducted for the analysis of ionic species and trace elements in solid waste material. This was accomplished by a distilled-water laboratory leachate generation procedure. This technique was designed to mimic the leachability of inorganic species under actual environmental conditions.

Aqueous leachates were then characterized by both SSMS and AA. Ion chromatography was employed to characterize a series of ionic species.

Sample Preparatory Procedures

Gaseous Stream Samples--

Gaseous effluent samples were collected using the Source Assessment Sampling System (SASS). This includes collection of inorganic species in both the XAD module and accompanying impinger train. XAD resin samples were prepared for analysis by combustion over 1:1 nitric acid in a Parr oxygen bomb. Approximately 1 gram of sample was weighed into a vycor dish; colloidion was added to each XAD sample to ensure complete combustion. The sample was then placed in the bomb, pressurized to 30 atmospheres with oxygen and ignited. For SSMS analysis, the bomb rinsings were combined with the remaining residue and mixed with graphite prior to electrode formation. For AA analysis the contents of the bomb were washed into a beaker, filtered and diluted to 50 ml prior to analysis.

Impinger samples and other liquid samples required no additional preparation for either SSMS or AA analysis.

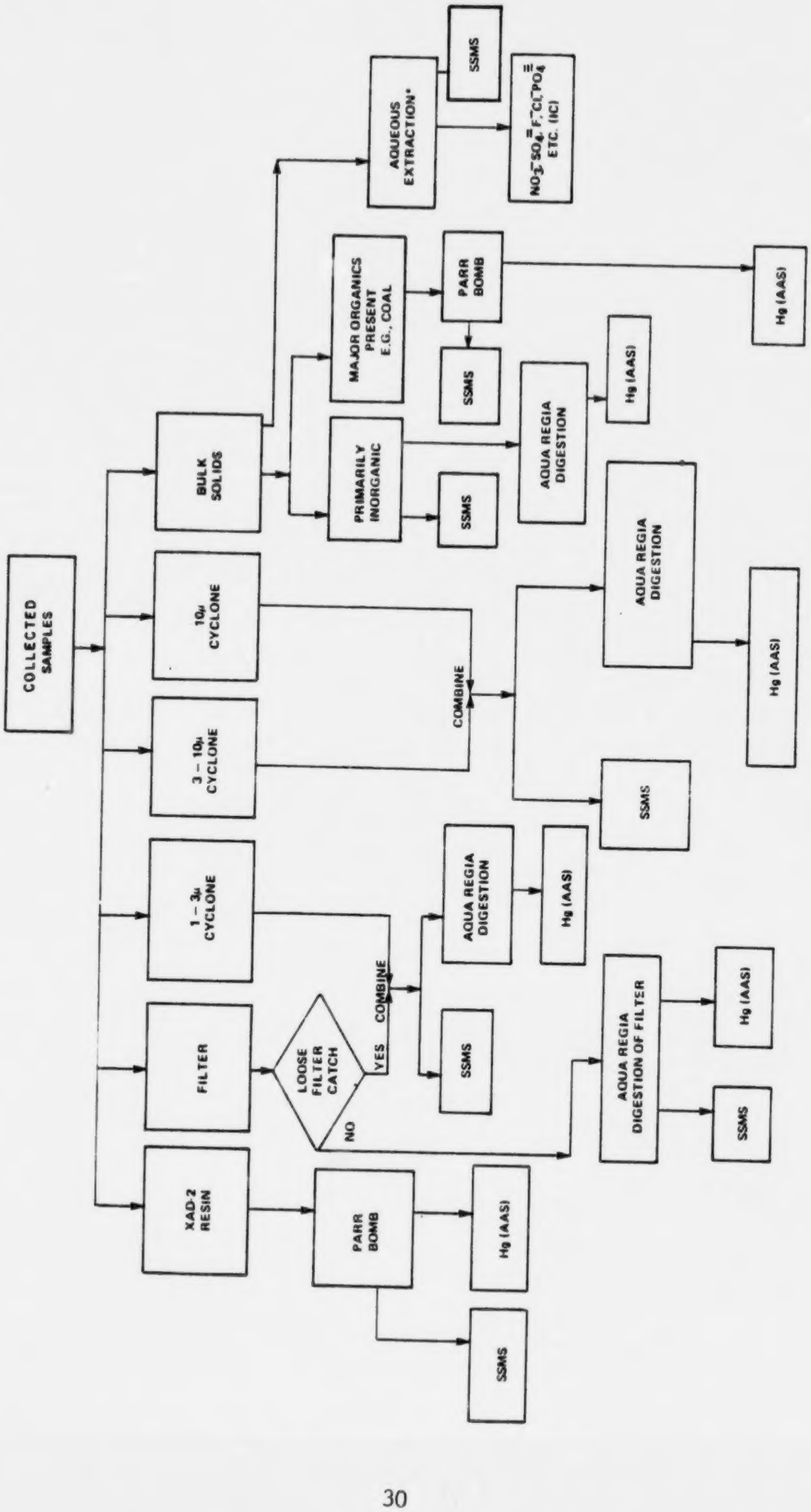
COLLECTED SAMPLES
XAD-2 RESIN
FILTER
1 – 3μ CYCLONE
3 – 10μ CYCLONE
10μ CYCLONE
BULK SOLIDS
PARR BOMB
Hg (AAS)
SSMS
LOOSE FILTER CATCH
YES
NO
COMBINE
AQUA REGIA DIGESTION
AQUA REGIA DIGESTION OF FILTER
PRIMARILY INORGANIC
MAJOR ORGANICS PRESENT E.G., COAL
AQUEOUS EXTRACTION*
NO3⁻ SO4⁼ F⁻ Cl⁻ PO4≡ ETC. (IC)

Figure 7. Level 1 Inorganic Laboratory Analysis Plan.

TABLE 10. SUMMARY OF INORGANIC ANALYSES PERFORMED ON EXXON MINIPLANT PFBC SAMPLES

Sample description	Analytical techniques			
	SSMS	AA	IC	Aqueous extraction[c]
Diluted combustor flue gas[a]				
SASS coarse (3-10 μm) particles	X	X		
SASS fine (1-3 μm) particles	X	X		
SASS particulate (<1 μm) filter	X	X		
SASS XAD-2 resin	X	X		
SASS impinger train		X	X	
Regenerator flue gas[b]				
SASS XAD-2 resin	X	X		
Bulk solid samples				
ESP hopper ash	X	X		
Regenerator cyclone ash	X	X	(X)[d]	X
Spent combustor bed material	X	X	(X)	X
Second combustor solids	X	X	(X)	X
Third combustor solids	X	X	(X)	X
Coal feed	X	X	(X)	X
Sorbent feed	X	X	(X)	X

[a] Undiluted combustor flue gas was sampled with an SASS XAD-2 module only. Dilution air was also sampled but not analyzed.

[b] Regenerator flue gas particles were below Level 1 weight criteria and were not analyzed.

[c] Laboratory-generated, distilled-water leachates.

[d] IC was run on leachates only. SSMS and AA were run on leachate samples to quantify trace elements (see text).

Solid Samples--

Solid sample types included both bulk solids (e.g., coal, fly ash) and flue gas particulates.

Particulate samples were prepared for atomic absorption analysis by extraction with 4:1 nitric-hydrochloric acid. Approximately 1 gram of sample was placed in a distillation flask with 60 ml of the acid mixture and refluxed for 6 hours. After cooling, the contents of the boiling flask were filtered, washed into a 100-ml volumetric flask and diluted to volume. SSMS analysis of particulates, with the exception of filters, required no additional preparation; filter samples were extracted using the acid mixture discussed previously.

An alternate extraction procedure, ASTM D 3683-78, was used in the preparation of bulk solid waste streams and coal. This procedure involves dissolution of the sample using hydrofluoric acid and *aqua regia*; in the case of coal or other materials which are primarily organic, the sample must undergo low temperature ashing as a preliminary step.

Analytical Methods

Spark Source Mass Spectrometry--

Spark Source Mass Spectrometry (SSMS) was the primary method of inorganic analysis for the majority of Level 1 samples. The instrument used, a JEOL Analytical Instruments, Inc., Model JMS-01BM-2 Mass Spectrograph, is a high resolution, double focusing mass spectrometer with Mattauch-Herzog ion optics and ion sensitive photoplate detection. The instrument is designed to carry out high sensitivity trace element analysis of metals, powders or semiconductor type materials using an RF spark ion source. An aliquot of each sample to be analyzed must be incorporated into two electrodes which are mounted in the ion source of the mass spectrometer. The electrodes are decomposed by the application of a radio frequency (∿ 1 MHz) potential of about 4 kV; this induces a high energy electrical discharge in the form of a spark plasma which is composed primarily of elemental species. The positively charged ions contained in the plasma are accelerated and formed into an ion beam by a high potential electric field (∿ 30 kV); the beam is then focused to produce a mass spectrum which is recorded by an ion sensitive photoplate.

SSMS can be used to detect elemental concentrations at levels as low as 10^{-9} g (1 nanogram). Although the sensitivity varies somewhat, depending on the element of interest and the sample type, nearly all elements in the periodic table (exceptions are H, C, N, O and the inert gases) can be detected. When photoplate detection is used, all elements with mass in the range 6 to 240 can be detected simultaneously. Element concentration is derived from the intensities (optical density) of the mass spectral lines; methods for determining concentration data from photoplate spectral line densities vary somewhat in terns of their complexity and the corresponding precision and accuracy of the results. The photoplate interpretation procedures followed for this program and for Level 1 survey work in general are designed to yield concentration data accurate to within a factor of 2 for 70 elements.

Interferences result from the formation of multiple charged ions, ion clusters and molecular ions such as oxides, hydrides, hydroxides and carbides.

These interferences, coupled with the fact that the discharge conditions in the ion source are not easily reproduced, tend to limit the accuracy of the technique. SSMS is, however, a useful survey tool and is capable of providing semiquantitative results which are accurate within a factor of 2 or 3.

Table 11 shows SSMS operating parameters for the Exxon program. Typical detection limits for liquid and solid samples are shown in Tables 12 and 13, respectively.

TABLE 11. SSMS OPERATING PARAMETERS

Pulse repetition rate	1000 Hz
Pulse length	40 μsec
Magnet current	4.00 A
Accelerating voltage	28.3 kV
Analyzer pressure	4×10^{-9} torr
Source pressure	5×10^{-7} torr

Atomic Absorption--

Trace element determination for mercury and antimony in flue gas samples were made using atomic absorption spectrophotometry. This technique was also used in trace element determination on a series of sample leachates. AA involes the generation of a population of free, uncombined atoms in the ground state using either flame or flameless methods and subsequent exposure of this population to light at the characteristic absorption wavelength. The sample absorbance is then compared to standard absorbances. The concentrations which can be determined by this method range from parts per billion to several hundred parts per million in solution. All atomic absorption analysis was done using a Perkin-Elmer Model 460 spectrophotometer equipped with deuterium arc background correction and Perkin-Elmer HGA-2100 Graphite Furnace. The operating parameters for mercury and antimony are shown in Table 14.

Antimony analyses were done using graphite AA. Sample volumes of 20 or 50 μl were injected into the furnace and the resulting absorbance compared to standard absorbances. Solution detection limits for these elements are on the order of 5 μg/l (equivalent to emissions of 0.25 $\mu g/m^3$).

Mercury was quantified using the cold vapor method. In this procedure all mercury was initially oxidized to the Hg^{+2} state by the addition of nitric and sulfuric acids to the sample aliquot; the sample was then diluted to a known volume and placed in the reaction vessel. The mercury was reduced to the elemental state by the addition of stannous chloride and aerated from solution in a closed system. The resulting absorbance value was then compared to standard absorbances. The detection limit for this procedure is 1 μg/l (equivalent to 0.05, 0.25, and 0.0033 $\mu g/m^3$ emissions in impingers, XAD, and particulate samples, respectively).

LEACHATE ANALYSIS

Leachate analyses were designed to give an estimate of the relative environmental hazard resulting from the aqueous leaching of bulk solid wastes from the Exxon Miniplant. Chemical characterization of the leachate from

TABLE 12. SSMS DETECTION LIMITS FOR TYPICAL 50 ml LEACHATE SAMPLE

Element	Value (ppm)	Element	Value (ppm)
U	<0.001	RU	<0.001
TH	<0.001	MO	<0.001
BI	<0.001	NB	<0.001
PB	<0.001	ZR	<0.001
TL	<0.001	Y	<0.001
HG	<0.001	SR	<0.001
AU	<0.001	RB	<0.001
PT	<0.002	BR	<0.001
IR	<0.001	SE	<0.001
OS	<0.001	AS	<0.001
RE	<0.001	GE	<0.001
W	<0.001	GA	<0.001
TA	<0.001	ZN	<0.001
HF	<0.001	CU	<0.001
LU	<0.001	NI	<0.001
YB	<0.001	CO	<0.001
TM	<0.001	FE	<0.001
ER	<0.001	MN	<0.001
HO	<0.001	CR	<0.001
DY	<0.001	V	<0.001
TB	<0.001	TI	<0.001
GD	<0.001	SC	<0.001
EU	<0.001	CA	<0.001
SM	<0.001	K	<0.001
ND	<0.001	CL	<0.001
PR	<0.001	S	<0.001
CE	<0.001	P	<0.001
LA	<0.001	SI	<0.001
BA	<0.001	AL	<0.001
CS	<0.001	MG	<0.001
I	<0.001	NA	<0.001
TE	<0.001	F	<0.001
SB	<0.001	B	<0.001
SN	<0.001	BE	<0.001
CD	<0.001	LI	<0.001
AG	<0.001		
PD	<0.001		
RH	<0.001		

SECTION 1

SUMMARY OF EXXON MINIPLANT PFBC SOURCE TEST AND EVALUATION

INTRODUCTION

In May 1979 GCA/Technology Division conducted a detailed sampling program at the Exxon Miniplant pressurized fluidized-bed combustor (PFBC) operating with sorbent regeneration as part of the complete Environmental Assessment of fluidized-bed technology.*

Sampling and analysis was conducted at the Miniplant in accordance with the phased approach to environmental assessment of energy and industrial processes which has been developed by the U.S. Environmental Protection Agency through their Industrial Environmental Research Laboratory at Research Triangle Park, NC (IERL-RTP). The phased environmental assessment methodology is designed to permit comprehensive analysis of multimedia pollutants in industrial emission streams in a cost-effective manner. Three levels of chemical, physical, and biological testing are included in this program. Level 1 testing provides a screening process which serves to rank emission streams from a source by potential hazard to man or the environment, thus identifying streams for further, more intensive (Level 2) analysis. This Source Test and Evaluation Report presents the results of the Level 1 sampling and analysis program conducted by GCA at the Exxon Miniplant PFBC operating with sorbent regeneration.

A description of the Exxon Miniplant as it operated during the Level 1 sampling program, combustor and regenerator operating conditions, and stream flow rates may be found in Section 2. Details of sampling techniques and analytical methods employed to quantify inorganic and organic chemical species and biological activity of Exxon samples are in Sections 3 and 4, respectively. Sampling and analysis was conducted based on the procedures specified in the Level 1 Procedures Manual.[1] Any variation from Level 1 protocols are discussed.

SUMMARY OF TEST RESULTS

Data generated from Level 1 analyses of Exxon samples were of three general types: inorganic analysis relying upon spark source mass spectroscopy (SSMS), atomic absorption spectrometry (AA), or wet chemical techniques;

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*GCA Corporation, GCA/Technology Division, conducted the field measurement under U.S. Environmental Protection Agency Contract No. 68-02-2693; Exxon Research and Engineering operated the Miniplant and supported the field program under U.S. Environmental Protection Agency Contract No. 68-02-1312.

TABLE 13. AVERAGE SSMS DETECTION LIMITS FOR 50 mg EXXON PARTICULATE SAMPLE

Element	Value (ppm)	Element	Value (ppm)
U	<0.68	RU	<0.50
TH	<0.96	MO	<0.31
BI	<0.41	NB	<0.23
PB	<0.93	ZR	<0.57
TL	<0.50	Y	<0.23
HG	<1.0	SR	<0.13
AU	<0.60	RB	<0.041
PT	<1.8	BR	<0.69
IR	<0.93	SE	<0.32
OS	<1.0	AS	<0.14
RE	<0.64	GE	<0.21
W	<0.43	GA	<0.088
TA	<0.64	ZN	<0.18
HF	<2.1	CU	<0.092
LU	<0.52	NI	<0.21
YB	<0.38	CO	<0.091
TM	<0.22	FE	<0.091
ER	<0.65	MN	<0.046
HO	<0.11	CR	<0.030
DY	<0.37	V	<0.067
TB	<0.072	TI	<0.082
GD	<0.37	SC	<0.073
EU	<0.26	CA	<0.041
SM	<0.78	K	<0.008
ND	<0.54	CL	<0.14
PR	<0.14	S	<0.12
CE	<0.19	P	<0.051
LA	<0.39	SI	<0.020
BA	<0.29	AL	<0.009
CS	<0.034	MG	<0.012
I	<0.12	NA	<0.004
TE	<0.45	F	<0.13
SB	<0.33	B	<0.063
SN	<0.39	BE	<0.008
CD	<0.11	LI	<0.002
AG	<0.17		
PD	<0.62		
RH	<0.16		

each of the bulk solid waste materials was accomplished through the combined use of Ion Chromatography (IC), Atomic Absorption (AA) and Spark Source Mass Spectrometry (SSMS).

TABLE 14. ATOMIC ABSORPTION OPERATING PARAMETERS FOR PERKIN-ELMER 460 SPECTROPHOTOMETER WITH HGA-2100 GRAPHITE FURNACE

Parameter	Element	
	Sb	Hg
Source	HCL/6 mA[a]	HCL/6 mA[a]
Wavelength (nm)	193.6	253.6
Slit (nm)	0.7	0.7
Drying time/temperature	110°C/30 sec	NA[b]
Charring time/temperature	500°C/30 sec	NA[b]
Atomizing time/temperature	2700°C/10 sec	NA[b]

[a] Hollow cathode lamp.

[b] NA = not applicable.

Preparatory Procedures - Leachate Generation

Fifty grams of solid material was dried at 104 ± 2°C for 18 ± 2 hours to determine the percentage of moisture in the sample. If necessary, the drying was repeated until a constant weight was achieved.

A representative sample of waste (350.0 grams) was weighed to the nearest tenth of a gram in a 2-liter LPE bottle.

Distilled, deionized water was boiled and cooled to maintain an approximate starting pH of 6.0 (ASTM Type IV water). The quantity of water added (1400 ml) was equal to four times the weight in grams of the sample.

The container was closed and agitated continuously for 48 ± 0.5 hours at 20 ± 2°C. The samples were shaken at 60 1-inch strokes per minute.

After 48 hours, the aqueous phase was separated by filtering through a 0.45 μm Millipore membrane filter.

An 8-ounce LPE bottle was completely filled with the filtrate (~275 ml) and refrigerated for future IC analysis. Another portion of the extract was acidified to pH 2 with 1:1 Ultrex nitric acid for AA and SSMS analysis.

Analytical Methods - Leachates

Ion Chromatography--

The anionic analyses of the leachates were accomplished usign a Dionex Model 14 Ion Chromatograph. The column system employed: (1) a precolumn (3 × 150 mm) to remove particulates, strongly retained anions, and organic species; (2) a separator column (3 × 500 mm) in the HCO_3^- form to chromatographically separate the anions; and (3) a suppressor column (6 × 250 mm) in the H^+ form to remove the background conductivity of the eluent. A solution of 0.003 M $NaHCO_3$/0.0024 M Na_2CO_3 was used for the eluent at a 30 percent flow rate (about 140 ml/hr). The injection loop had a volume of 100 µl and the sample was introduced from a 5 ml disposable syringe fitted with a 0.22 µm Millipore filter to remove particulate matter. A 1 N H_2SO_4 solution regenerated the suppressor column for 15 minutes after an 8-hour period.

Detection limits for the IC analyses are given in Table 15.

TABLE 15. IC DETECTION LIMITS

Anion	Detection limit (µg/l)
F^-	50
Cl^-	100
Br^-	100
NO_2^-	80
NO_3^-	100
SO_4^{2-}	100
PO_4^{3-}	100

Figure 8 represents a typical chromatogram for a mixed anion standard mixture. Figure 9 illustrates an ionic chromatogram resulting from the analysis of the secondary combustor cyclone leachate. The sample depicted in Figure 10 represents a 1:25 dilution of the sample shown in Figure 9. The latter step was implemented to permit quantification of the sulfate ion.

AA Analysis of Leachates--

The atomic absorption analyses of the leachates were performed using a Perkin-Elmer Model 460 Spectrophotometer, equipped with deuterium arc background correction. The metals determined in the leachates included silver, arsenic, barium, cadmium, chromium, mercury, lead, selenium, and calcium. All metals, except Ca and Hg, were analyzed by the flamelsss AA technique with a Perkin-Elmer HGA-2100 Graphite Furnace. The operating parameters for each element are listed in Table 16. The drying, charring, and atomization cycles were optimized for each element. Data for the standard solutions and leachate samples were recorded in the peak height mode of the instrument. Aliquot volumes of 50 of 25 µl were pipetted into the furnace with an Eppendorf pipet. For the analyses of As and Se, an equal volume of a 1000 ppm Ni solution (as $Ni(NO_3)_2$ was added to the furnace.

Calibration curves were used to quantify the data and determine the linear working ranges for the metals. The standard solutions were prepared

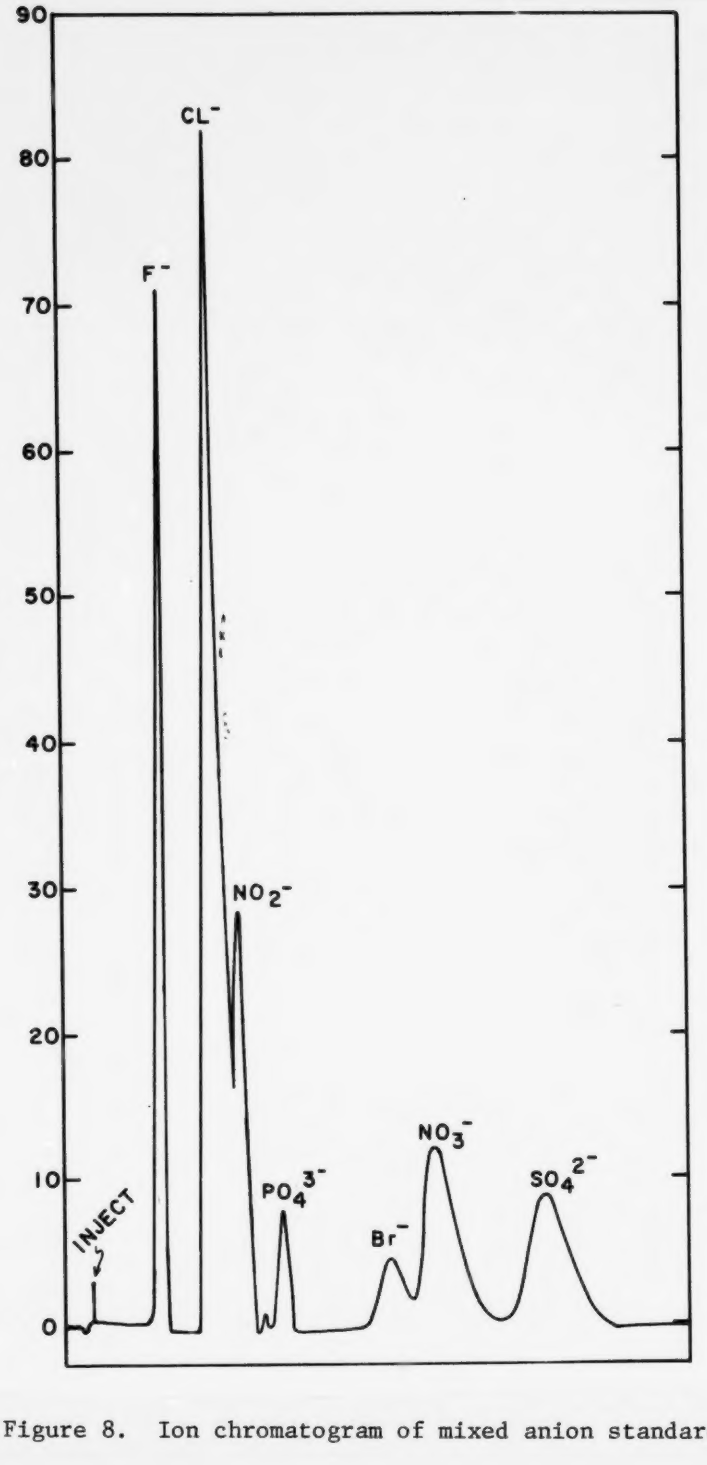


Figure 8. Ion chromatogram of mixed anion standard.

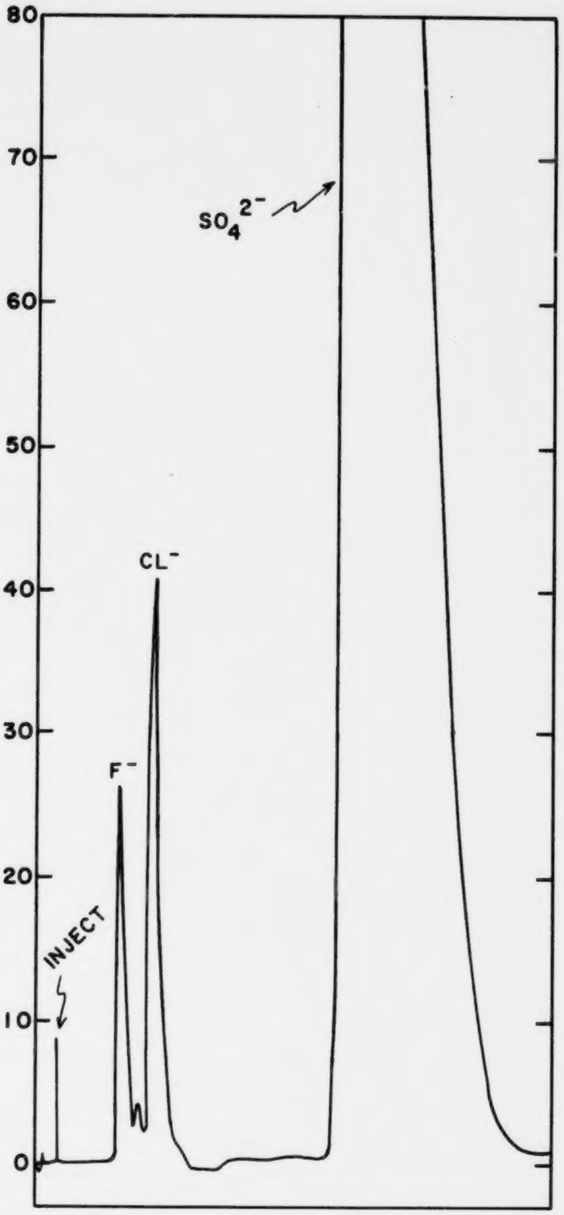


Figure 9. Ion chromatogram of secondary combustor cyclone leachate (EX 1-1-07-FA_2)

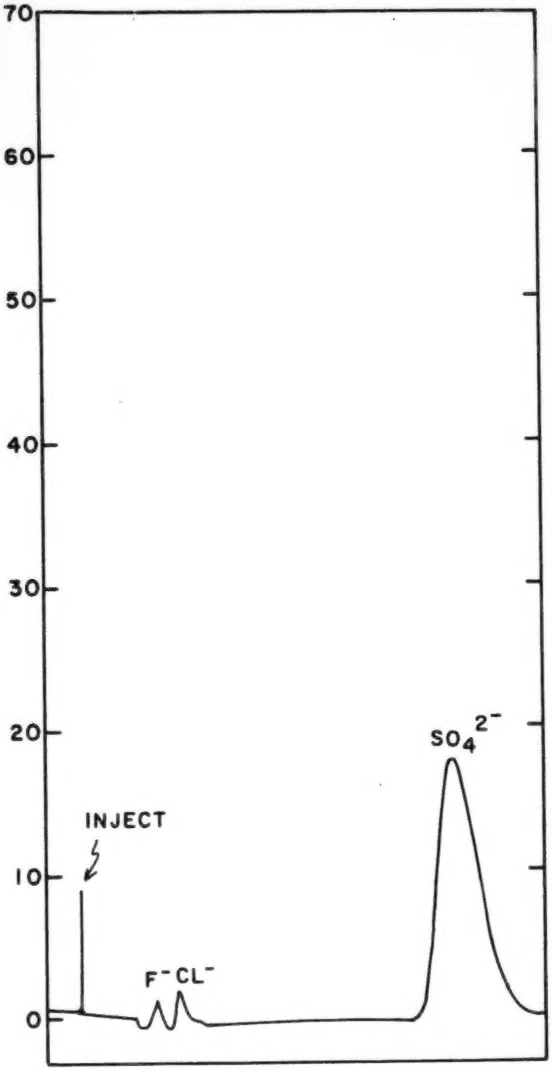


Figure 10. Ion chromatogram of secondary combustor cyclone leachate (diluted 1:25).

TABLE 16. OPERATING PARAMETERS FOR FLAMELESS AA ANALYSES OF LEACHATES

Parameter	Ag	As	Ba	Cd	Cr	Pb	Se
Source	HCL[a]	EDL[b]	HCL	EDL	HCL	HCL	EDL
Wavelength (nm)	327.8	193.6	553.4	228.5	357.7	283.2	196
Slit (nm)	0.7	0.7	0.2	0.7	0.7	0.7	0.7
Background correction	No	No	No	No	No	No	No
Purge gas	Ar	Ar	Ar	Ar	Ar	Ar	Ar
Gas interrupt	No	Yes	No	Yes	Yes	Yes	Yes
Drying temperature/time	120°C/30 sec	120°C/40 sec	120°C/40 sec	120°C/30 sec	120°C/40 sec	120°C/30 sec	120°C/30 sec
Charring temperature/time	400°C/30 sec	500°C/30 sec	600°C/30 sec	350°C/30 sec	1100°C/30 sec	500°C/30 sec	700°C/40 sec
Atomization temperature/time	2700°C/10 sec	2700°C/10 sec	2700°C/10 sec	2100°C/10 sec	2700°C/10 sec	2300°C/10 sec	2700°C/10 sec

[a] HCL = hollow cathode lamp.

[b] EDL = electrodeless discharge lamp.

in deionized water which had been acidified to pH <2 with Baker Ultrex nitric acid. For quality control purposes, EPA trace metal samples were analyzed. Some leachates were also analyzed by the method of standard additions to ensure that no matrix interferences existed.

Since the concentration of calcium in the leachates was found to be in the ppm range, calcium was analyzed in a nitrous oxide-acetylene flame, with the results recorded in the absorption mode. The ionization interferences present with the nitrous oxide-acetylene flame were controlled by the addition of a 2,000 ppm potassium solution. Mercury was analyzed using the cold vapor AA technique described previously.

Detection limits for the flameless AA analyses are given in Table 17.

TABLE 17. DETECTION LIMITS FOR FLAMELESS ATOMIC ABSORPTION ANALYSES

Metal	Graphite furnace (ppb) (μg/l)
Ag	0.5
As	1.0
Ba	1.0
Cd	0.1
Cr	1.0
Pb	1.0
Se	5.0
Hg	1.0[a]

[a] Cold vapor method.

QUALITY CONTROL OF INORGANIC ANALYSIS PROCEDURES

Data quality from the inorganic analytical program was monitored by means of NBS Standard Reference materials coded as Level 1 samples. SRM 1632, Trace Elements in Coal and SRM 1633, Trace Elements in Coal Fly Ash were chosen as being the most appropriate materials since their matrices are similar to those of the Exxon samples. The results of the SSMS and AA analysis are shown in Tables 18 and 19, respectively.

Analyses conducted using Level 1 procedures are required to produce final results accurate to within a factor of 3. In general, the SSMS data met this criterion. The exceptions were the major components (Si, Al, Mg, Na, CA), as well as chlorine and iodine. The concentrations of the major components were too high to be reliably reported by SSMS; in such cases, it was judged best to report the element as a "major component," rather than attempt to assign a value which might have been misleading. One suggested alternative was to rerun a smaller aliquot of the appropriate sample to obtain more accurate quantitative measurements. This option, however, was not always possible due to the diminutive sample size on the Exxon particulate catches.

TABLE 18. ANALYSIS OF SRM 1633 BY SSMS

Element	Reported concentration (µg/g)	Expected concentration (µg/g)	Factor difference
U	6.6	11.6[a]	-1.8
Th	37	24[b]	1.5
Pb	72	70[a]	1.0
Tl	6.1	4[b]	1.5
Ce	180	146	1.2
La	120	82[c]	1.5
Ba	3400	2700[c]	1.3
Cs	5.2	8.6[c]	-1.7
I	0.63	2.9[c]	-4.6
Sb	8.5	6.9[c]	1.2
Cd	1.9	1.45[a]	1.3
Sr	2900	1400[b]	2.1
Rb	110	112[b]	1.0
Se	13	9.4[a]	1.4
As	93	61[a]	1.5
Zn	210	216[c]	1.0
Cu	140	128[a]	1.1
Ni	240	98[a]	2.5
Co	59	38[b]	1.6
Fe	57000	62000[c]	-1.1
Mn	240	493[a]	-2.1
Cr	59	131[a]	-2.2
V	350	214[a]	1.6
Ti	4300	7400[c]	-1.7
Ca	73000	4300[c]	17
K	4800	2800[c]	+1.7
Cl	140	890[c]	-6.4
Si	38000	21000[c]	-5.5
Al	12000	127000[c]	-10.6
Mg	2700	18000[c]	-6.7
Na	530	3200[c]	-6.0
Be	5.0	12[b]	-2.4
Br	14	12[c]	1.1

[a] NBS certified.

[b] NBS information.

[c] Ondov. (Anal Chem 47. 7-1102-1109 (1975).

TABLE 19. ANALYSIS OF SRM 1632 AND 1633 BY AAS

	Reported concentration (μg/g)	NBS value (μg/g)	Factor
SRM 1632	0.11	0.12 ± 0.02	-1.1
SRM 1633	0.10	0.14 ± 0.01	-1.4

The cold vapor mercury method appears to produce acceptable Level 1 data. The mercury value reported for the NBS coal is within the error limits defined by NBS. The value reported for NBS No. 1633 is outside the reported error limits, however, repeated analysis of NBS No. 1633 in our laboratory using Level 1 procedures has produced a value of 0.11 ± 0.02 μg/g Hg for this sample; the result reported here is within those limits.

NBS 1632 coal was analyzed by SSMS after preparation by Parr Bomb combustion; the results were much lower than the expected value. Since it was thought that the preparation procedure might at fault, the coal was prepared by an alternate procedure using low temperature ashing followed by hydrofluoric acid — aqua regia digestion. The alternate procedure produced significantly better results for the majority of elements.

ORGANIC LABORATORY ANALYSIS PROCEDURES

Introduction

The analytical measurements performed on Exxon samples to quantify organic species was accomplished using a multisegmented approach. Preliminary analyses were those specified in the Level 1 Procedures Manual (see Figure 11). This approach identifies major organic compound classes within each sample stream tested. Qualitative and quantitative data are generated from the combined use of gravimetry (GRAV), determination of total chromatographable organics (TCO), infrared spectroscopy (IR) and, where Level 1 decision criteria dictate, low resolution mass spectrometry (LRMS) and liquid chromatographic separation (LC) (see Figure 11). Table 20 summarizes the Level 1 organic analyses performed on indicated Exxon samples.

Organic analysis of certain Exxon samples was extended to include a technique beyond the recommended Level 1 protocol. This added facet of the organic analytic approach consisted of compound-specific analysis provided by the combined use of high performance liquid chromatography and fluorescence detection (HPLC/Fluorescence). This procedure was used to characterize polynuclear aromatic hydrocarbon (PNA) species. Details of these analyses will be presented in a later section.

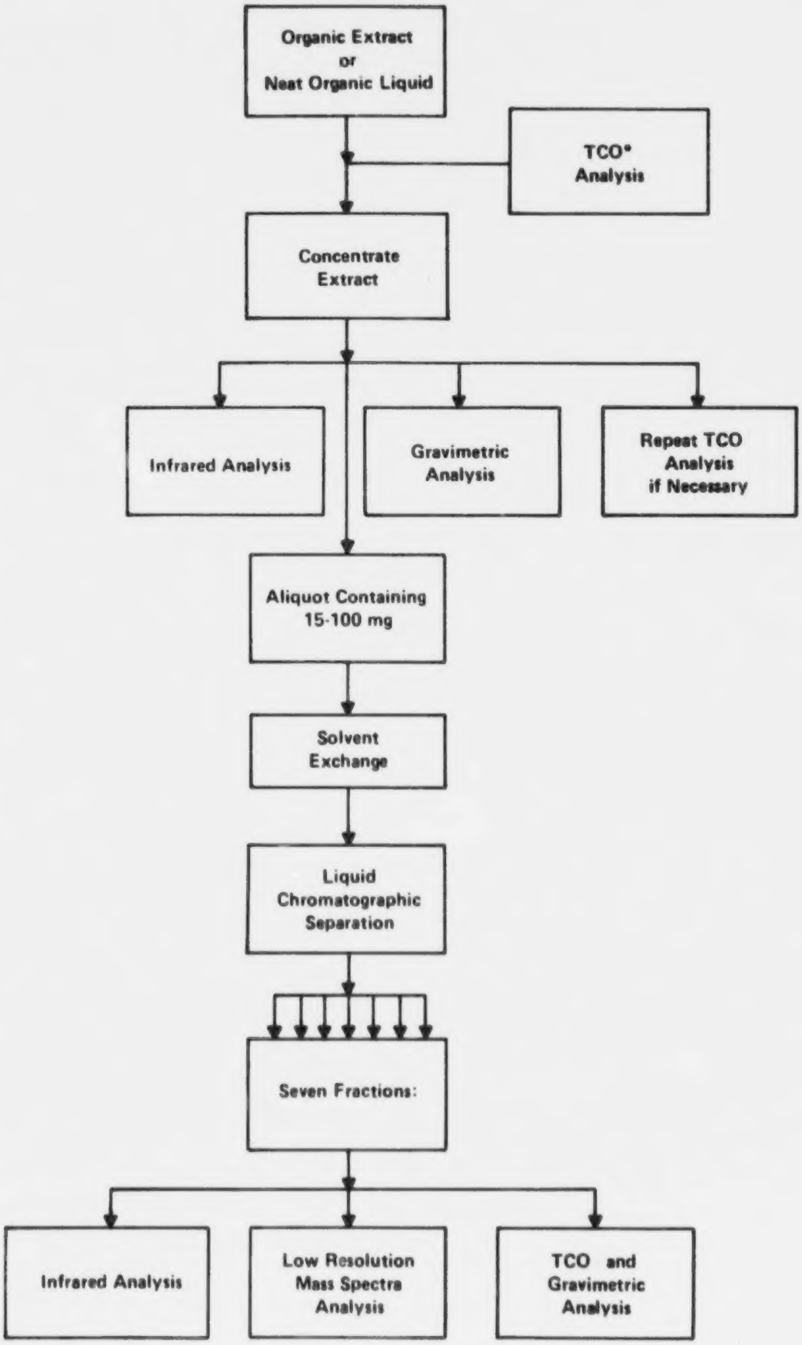

Organic Extract
or
Neat Organic Liquid
TCO*
Analysis
Concentrate
Extract
Infrared Analysis
Gravimetric
Analysis
Repeat TCO
Analysis
if Necessary
Aliquot Containing
15-100 mg
Solvent
Exchange
Liquid
Chromatographic
Separation
Seven Fractions:
Infrared Analysis
Low Resolution
Mass Spectra
Analysis
TCO and
Gravimetric
Analysis

Figure 11. Organic analysis methodology.[1]

TABLE 20. SUMMARY OF LEVEL 1 ORGANIC ANALYSES PERFORMED ON EXXON MINIPLANT PFBC SAMPLES

Sample description	CH_2Cl_2-extraction	TCO	GRAV	IR	LRMS	LC[g]
Diluted combustor flue gas[a]						
SASS train components						
Combined coarse (3-10 μm) particles	X	-[e]	X	X	X	-
Combined fine (<3 μm) particles	X	-	N[f]	X	X	-
Sorbent module condensate	X	X	X	X	-	-
XAD-2 resin and module rinse	X	X	X	X	X	X
Undiluted combustor flue gas[b]						
SASS train components						
Sorbent module condensate	X	X	X	X	-	-
XAD-2 resin and module rinse	X	X	X	X	X	-
Regenerator flue gas[c]						
SASS train components						
Sorbent module condensate	X	X	X	X	-	-
XAD-2 resin and module rinse	X	X	X	X	X	X
Dilution air[d]						
SASS train components						
XAD-2 resin and module rinse	X	X	X	X	-	-
Bulk solids						
ESP hopper ash	X	X	X	X	X	-
Regenerator cyclone ash	X	X	X	X	X	-
Spent combustion bed material	X	X	X	X	X	-
Second combustor cyclone catch	X	X	X	X	-	-
Third combustor cyclone catch	X	X	X	X	-	-
Cool feed	X	X	X	X	X	-
Sorbent feed	X	X	X	X	X	-

[a] Analyses were performed on samples taken on day 3 (EX 1-3-01).

[b] Analyses were performed on samples taken on day 1 (EX 1-1-02)

[c] Analyses were performed on samples taken on days 1 and 2 (EX 1-1-03, EX 1-2-03).

[d] Analyses were performed on samples taken on days 1 and 2 (EX 1-1-04, EX 1-2-04).

[e] - = Not analyzed.

[f] N = No data, blank correction problems.

[g] Samples which were LC separated had subsequent TCO, GRAV and IR analysis of fractions as per Level 1 protocol (see Reference 1).

Sample Preparation

Sample preparation for organic analysis of gaseous stream samples consisted of extraction of the adsorbent resin (XAD-2) cartridges used as part of the sampling trains (see Section 3).

Each of the sorbent/module rinses was aliquotted and combined prior to extraction. The extraction sequence took place in a soxhlet extractor using methylene chloride for 24 hours. The extracts were concentrated to 10.0 ml via rotary evaporation under reduced pressure at 35°C.

Analytical Methods

Brief descriptions of the analytical techniques used in conduction organic analysis of Exxon Miniplant PFBC samples are presented below. Included is a discussion of the HPLC/Fluoresence procedures used to provide data on concentration of PNA species in certain indicated samples. Where appropriate, samples of typical data output from some analytical techniques are included.

Gravimetry--

The purpose of the gravimetric analysis is to quantify organic constituents with boiling points greater than 300°C. Typical analyses consist of pipetting a 1.0 ml aliquot of each 10.0 ml sample extract into a precleaned and tared aluminum weighing pan. After a period of sample desiccation, to remove residual solvent, each sample is weighed to a constant weight of ± 0.1 mg.

While the analysis is useful in the assessment of total nonvolatile organics residues, errant values may result from positive interferences from inorganic constituents. During preliminary gravimetric analysis residues from both the regenerator and undiluted combustor flue gas samples contained significant quantities of elemental sulfur (mw = 256). The interpretation of these gravimetric measurements was somewhat complicated as a result.

Total Chromatographable Organics--

Chemical analysis of moderately volatile organic materials (B.P. 100°-300°C) was accomplished by gas chromatography coupled with flame ionization detection. A summary of instrument operating conditions is presented in Table 21. This technique is designed to provide both qualitative and quantitative information on appropriate sample extracts. The qualitative analysis divides each sample into discrete boiling point ranges, which are defined by a mixture of n-alkanes (C_7-C_{17}). This is accomplished through the use of retention time data recorded for standard mixtures of these materials. Figure 12 depicts a typical chromatogram of an n-alkane mixture (C_7-C_{17}) including suggested boiling point boundaries for each alkane region. Figure 13 is an example of a chromatogram from TCO analysis of an Exxon stram sample (Regenerator flue gas EX 1-2-03).

In a similar manner, quantitative calibration for this procedure is provided by instrument response to a mixture of normal hydrocarbon (C_8, C_{12}, C_{16}).

TABLE 21. TOTAL CHROMATOGRAPHABLE ORGANICS (TCO) - OPERATING PARAMETERS

Parameter	Description
Instrument:	Tracor 560 gas chromatograph with dual FID
Recorder/integrator:	Hewlett-Packard 3380S
Chart speed:	1 cm/min
Column:	10 percent SP-2100 on Supelcoport 100/120 6 ft × 2 mm id glass column
Carrier gas:	20 ml/min prepurified N_2
Oven temperature:	50°C for 5 min, programmed 50°-250°C at 10°/min, hold at 250°C for 2 min
Injector temperature:	275°C
Detector temperature:	300°C
Injection volume:	2.0 μl

During the course of these analyses problems with precipitated elemental sulfur were encountered with both the regenerator and undiluted combustor flue gas samples. Per Level 1 protocol, each of the extracts noted was restored to a measured volume sufficient to dissolve the precipitated species prior to further analysis.

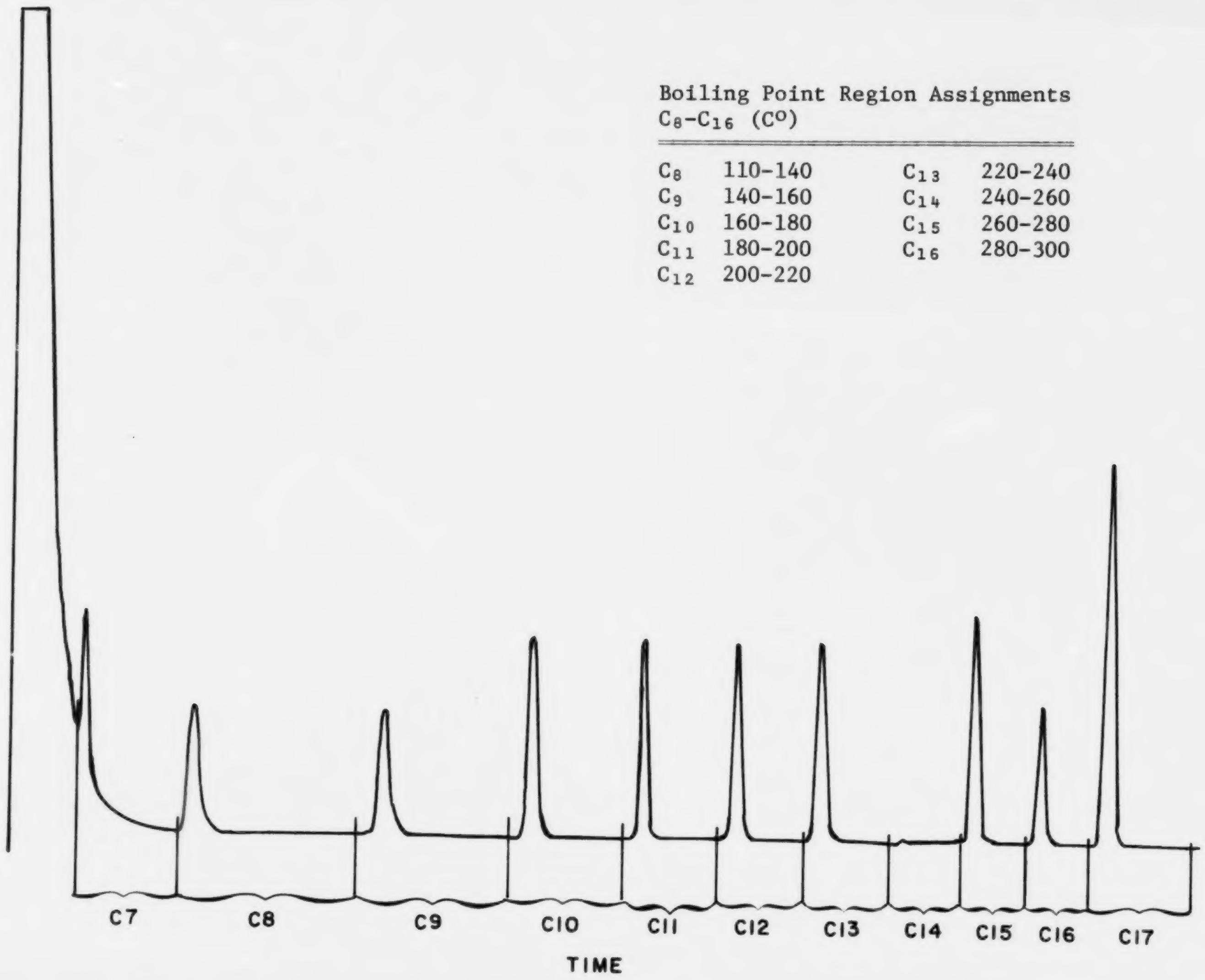
Solid samples--Solid samples designated for organic analysis are listed in Table 20. This included all SASS cyclones and particulate filter catches, probe rinses and bulk solid samples. Preliminary analysis of bulk solids consisted of sample homogenization using riffling techniques.

Typically, 100 grams of each of the bulk solid sample was extracted for 24 hours in a soxhlet apparatus with methylene chloride. Each extract was then filtered, dried and concentrated to a final volume of 10.0 ml, using a rotary evaporator under reduced pressure at 35°C.

Liquid samples--Only the scrubber slurry sample was designated as a liquid process stream. A 6-liter sample of this stream was extracted with methylene chloride after each of two-sample pH adjustments (acid and base). The extracts were combined, dried and concentrated to 10.0 ml.

LC Separation--

This procedure was designed to separate samples into seven reasonably distinct classes of compounds and was applied to all organic samples which contained a minimum of 500 $\mu g/m^3$ of combined volatile (TCO) and nonvolatile



Boiling Point Region Assignments
C_8-C_{16} (C°)

C_8	110-140	C_{13}	220-240
C_9	140-160	C_{14}	240-260
C_{10}	160-180	C_{15}	260-280
C_{11}	180-200	C_{16}	280-300
C_{12}	200-220		

Figure 12. Chromatogram (TCO) of n-alkane calibration mixture for boiling point distribution analysis.

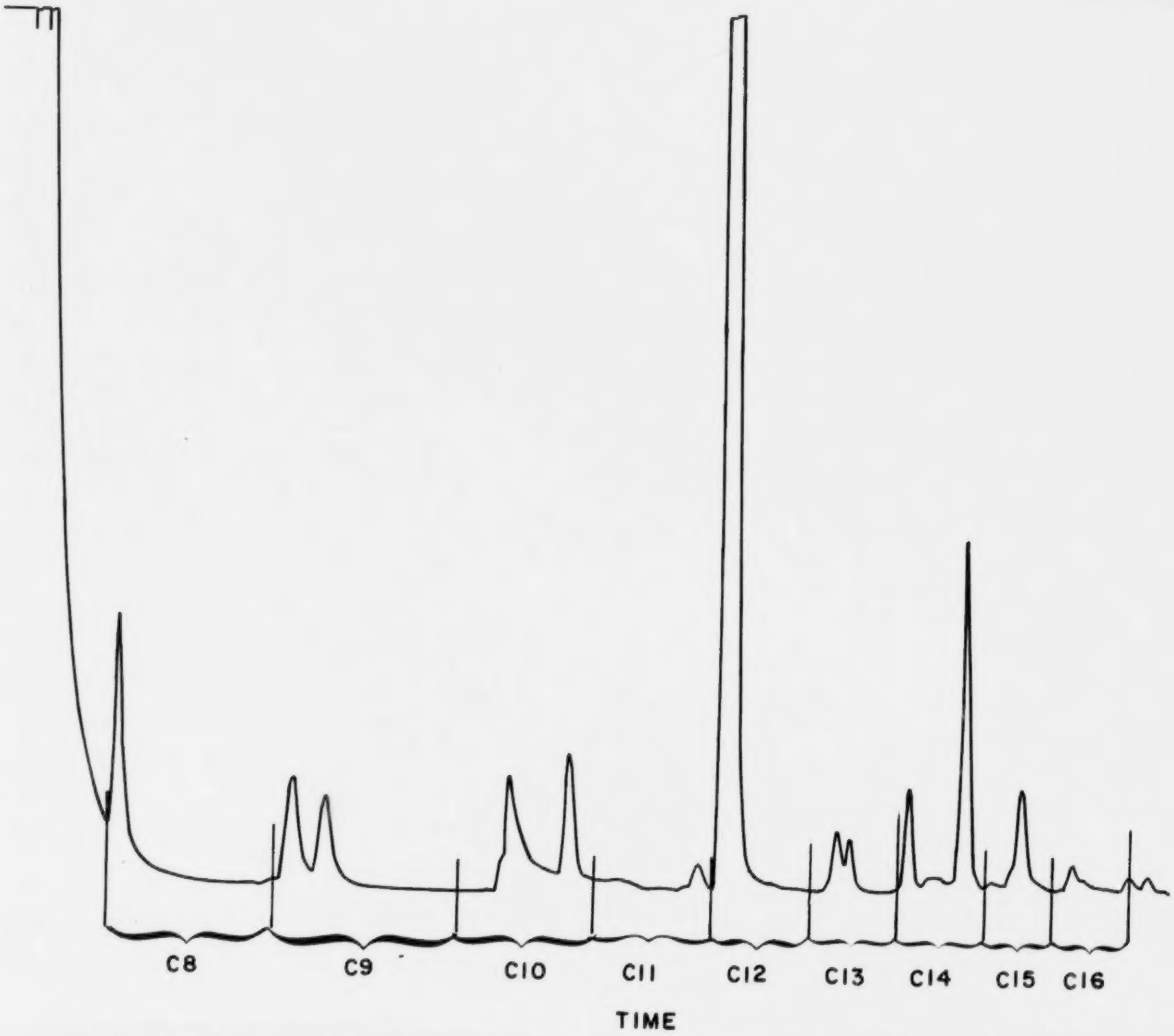


Figure 13. Chromatogram with alkane equivalent regions designated resulting from TCO analysis of Exxon regenerator flue gas (EX 1-2-03).

(gravimetric) organics. A sample was placed on a silica gel liquid chromatographic column, and a series of eluants of sequentially increasing polarity was employed to separate the sample into fractions for further analyses. Table 22 lists compound classes typically isolated in each fraction. Also shown are solvent compositions of each eluant.

Because of the limited organic loadings for the majority of the Exxon sample streams, LC fractionation was conducted in only two instances. Both the regenerator flue gas and diluted combustor flue gas were fractionated and each fraction further analyzed per Level 1 protocol. This included GRAV, TCO and IR measurement on each of the seven isolated fractions. Low resolution mass spectrometry (LRMS) was performed on fractions which contained >0.5 mg/m^3 of total organics.

Elemental sulfur residues were present in both the flue gas samples requiring LC fractionation. While the sulfur residues did not pose any difficulty in analysis of the diluted combustor sample residues did cause some difficulty in further characterization of the regenerator flue gas sample. Sulfur residues are suspected cause for the somewhat low column recovery observed (73 percent) in the regenerator sample. Sulfur artifacts were also detected in LRMS of several fraction. Similar problems were encountered with the infrared analyses (IR) of these fractions, prompting use of liquid cells to avert spectroscopic interferences from the precipitated sulfur.

Infrared Analysis--

IR analysis was used to determine the functional groups in an organic sample or LC fraction of a partitioned sample. The interpreted spectra provide information on functionality (e.g., carbonyl, aromatic hydrocarbon, alcohol, amine, aliphatic hydrocarbon, halogenated organic, etc.). Compound identification is possible only when that compound is known to be present as a dominant constituent in the sample.

During the course of this analytical program IR scans were conducted using either KBr plates or NaCl liquid cells.

For samples run on KBr plates, sample gravimetric residues were redissolved in a volume of methylene chloride and transferred to the plate in a final volume between 0.1 and 0.2 ml. For samples exhibiting high concentrations of volatile organics (TCO), neat sample extracts were used. Volumes applied varied between 0.1 and 2.0 ml, depending on the predetermined organic loading. Because of solvent interferences, a number of the extracts underwent solvent exchange into carbon disulfide prior to IR analysis using liquid cells. A solution of the sample was prepared in a volume of CS_2 ranging from 0.02 to 0.04 ml. The solution was transferred to the liquid cell and stoppered. All of the above sample types were subsequently scanned from 4000 cm^{-1} to 250 cm^{-1}. For a listing of instrument operating parameters, refer to Table 23.

TABLE 22. SUMMARY OF SUGGESTED ORGANIC CLASS DISTRIBUTION FOR LC FRACTIONATION SCHEME

Solvent fractions						
Fraction No. 1 pentane	Fraction No. 2 20% methylene chloride in pentane	Fraction No. 3 50% methylene chloride in pentane	Fraction No. 4 methylene chloride	Fraction No. 5 5% methanol in methylene chloride	Fraction No. 6 20% methanol in methylene chloride	Fraction No. 7 50% methanol in methylene chloride
1. Aliphatic hydrocarbons (alkanes) (alkenes) (alynes)	1. Halogenated aliphatics (saturated) (unsaturated)	1. Aromatic hydrocarbons (benzenes)	1. Nitro aromatic hydrocarbons	1. Nitro aromatic hydrocarbons	1. Alcohols (primary, secondary, tertiary) (glycols)	1. Sulfonic acids, sulfoxides
2. Halogenated aliphatics (saturated) (unsaturated)	2. Aromatic hydrocarbons (benzenes)	2. Halogenated aromatic hydrocarbons	2. Ethers (halogenated ethers)	2. Phosphates	2. Phenols (alkyl, etc.) (halogenated phenols) (nitrophenols)	2. Carboxylic acids
	3. Halogenated aromatic hydrocarbons	3. Fused alternate, nonalternate hydrocarbons, MW <216 (methyl pyrene) MW >216	3. Epoxides		3. Esters (phthalates	3. Phosphates
	4. Fused alternate, nonalternate hydrocarbons MW <216 (methyl pyrene) MW >216	4. Heterocyclic oxygen compounds	4. Aldehydes		4. Ketones	
	5. Silicones	5. Silicones	5. Heterocyclic oxygen compounds		5. Amines (primary, secondary, tertiary) (hydrazines, azo compounds) (Nitrosoamines)	
			6. Nitriles (aliphatic) (aromatic)		6. Heterocyclic nitrogen (quinolines, acridines)	
			7. Heterocyclic nitrogen compounds (indoles, carbazoles)		7. Alkyl sulfur compounds (mercaptans) (sulfides. disulfides)	
			8. Heterocyclic sulfur compounds (Benzo thiophenes)		8. Amides	
			9. Silicones		9. Carboxylic acids	
					10. Phosphates	

TABLE 23. OPERATING PARAMETERS FOR THE PERKIN-ELMER 283 INFRARED SPECTROPHOTOMETER

Parameter	Survey	Rescan
Scan time (min) (4000 $cm^{-1} \rightarrow 250\ cm^{-1}$	6	24
Vertical expansion	1X	2X or 5X
Slit	Normal	7
Response	1	2
Mode	% Transmission	Same

Interpretation of IR spectra was made in terms of functional groups present. Sample quantities required for analysis were in the (mg) range with a lower limit of approximately 0.5 mg. A single species must be present on a 5 to 10 percent (w/w) basis to warrant sufficient interpretation of stronger functional groups. For a listing of the more common functionalities with suggested peak intensities and typical detection limits (in $\mu g/m^3$), see Table 24. Figure 14 depicts a typical IR spectrum as recorded for the diluted combustor flue gas with the appropriate functional group assignments noted.

Low Resolution Mass Spectrometry--

This procedure is a survey analysis used to determine compound types in an organic sample or in an LC fraction of a sample. The analyst is specifically searching for hazardous compounds or compounds that may be generally considered toxic; e.g., aromatic hydrocarbons and chlorinated organics. Analysis using different sample ionizing parameters results in molecular weight data which, combined with IR and sample source data, can provide specific compound identifications on a "most probable" basis.

The mass spectrometer used in this procedure has sufficient sensitivity such that 1 nanogram or less presented to the ionizing chamber results in a full spectrum with a signal ratio of 10:1. A dynamic range of 250,000 is achievable. The detection limit for a specific compound related to the size of an air sample or liquid sample varies widely depending on the types and quantities of the species in the mixture. This is because of interfering effects in the spectrum caused by multiple compounds. The impact of this interference is reduced by lowering the ionization voltage to produce spectra containing relatively more intense molecular ions.

Analyses were performed on LC fraction containing source concentrations of organics exceeding the following levels.

Sample type	Concentration criteria
Gaseous (SASS)	0.5 mg/m^3
Solids	1 mg/kg
Aqueous	0.1 mg/l

TABLE 24. FUNCTIONAL GROUP IDENTIFICATION USING INFRARED SPECTROSCOPY - TYPICAL SPECIES DETECTION LIMITS AND PEAK INTENTISITES

Compound class	Peak intensity	Suggested detection limit ($\mu g/m^3$) for compound confirmation[d]
Aldehydes	Strong C=O Weak C=O I H	40 - 50
Aliphatics[a,b]	Medium	50
Amides[a]	Strong	12 - 17
Alcohols[a]	Medium	NA[e]
Aromatics[a]	Strong $<900\ cm^{-1}$ Medium $>900\ cm^{-1}$	10 - 30
Carboxylic acids[a,b]	Strong	23 - 37
Chlorinated hydrocarbons[a]	Medium	NA[e]
Esters[a]	Strong	3
Ketones[a]	Medium	NA[e]
Nitro (NO_2) compounds	Strong	30
Phenols	Medium	NA[e]
Phthalates	Strong	7

[a] This value was determined from an IR run in our laboratory. When actual laboratory data was unavailable, detection limits were determined from literature values of documented molar extinction coefficients. These were obtained from the following sources: (1) The Infrared Spectra of Complex Molecular by L. J. Bellamy 2nd edition, John Wiley and Sons, New York, 1958 and (2) Infrared Absorption Spectroscopy - Practical by Koji Nakaniski, Holden-Day Inc., San Francisco, Calif., 1962.

[b] This value is somewhat exaggerated, as it was derived from an IR spectrum of a GRAV residue.

[c] No information on IR absorption intensities or extinction coefficients of pure compounds was found.

[d] Above data assumes a 30 m^3 flue gas sample collected under SASS train conditions extracted and concentrated to 10.0 ml prior to analysis.

[e] While detection of this functionality is possible, it is difficult to confirm because either the range of wave numbers for confirmation is broad or because many different classes absorb where confirmatory peaks are found.

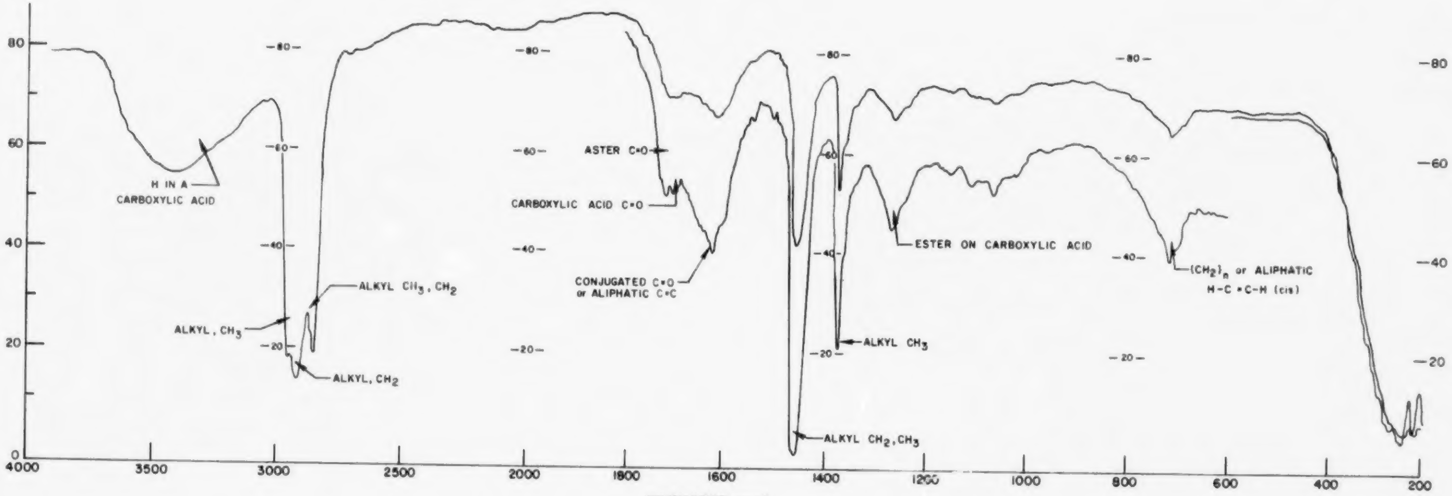


Figure 14. Infrared spectra with functional group assignments of diluted combustor flue gas - extract of organic module (EX 1-3-01 XM).

Mass spectral data interpretations were made only after proper evaluation of preexisting LC, IR, TCO and GRAV data.

LRMS samples were loaded in a closed end capillary tube such that the total gravimetric loading into the tube was approximately 1 microgram. The solvent was then removed by allowing the sample tube to heat to 40°C for approximately 10 minutes, depending on factors such as sample volume and solvent. The tube was then placed in the direct probe and introduced into the mass spectrometer. Mass spectrometer conditions are shown in Table 25.

TABLE 25. MASS SPECTROMETER CONDITIONS

Parameter	Description
Direct probe temperature	50°C to 300°C at 5°C/min
Sample size	Typically 1 μg
Source temperature	200°C
Emission	300° μa
Electron Energy	70 eV

Thermograms of the sample were then examined and evaluated using software available in the data system. Unknown spectra were interpreted using the 32,000-compound NBS Reference Library as an aid. Relative abundances were subjectively assigned to the identified compounds and reported on the basis of a 1, 10, or 100 concentration relative to the most concentrated compound. Complete LRMS results are given in Appendix A.

Considerable difficulty was encountered in analysis of these samples when high concentrations of sulfur were present, masking the spectra of other compounds which may have been present in the sample. Attempts at cleanup procedures, such as mercury shakedowns to complex out the sulfur, were moderately successful.

HPLC/Fluorescence--

Further chemical analyses of sample extracts included speciation of some potentially active organic mutagens. Because of the biological significance of low levels of polynuclear aromatic hydrocarbons, chemical characterization of these materials in Exxon samples was initiated. For this purpose, our investigation included HPLC/Fluorescence scanning of select sample extracts. This technique is used in our laboratory as a screening tool to isolate potentially mutagenic extracts based on sample fluorescence characteristics. Table 26 presents a list of PNA species screened for using HPLC/Fluorescence including detection limits.

Each of the sample extracts designated for further investigation was analyzed using the above technique. Prior to HPLC an aliquot of the sample was filtered through an FH 0.5μ Fluoropore filter and diluted with methanol. A 30 μl portion was analyzed under the conditions noted in Table 27. Anthracene was added to each extract prior to analysis to act as an internal

TABLE 26. PNA RESOLUTION AND SENSITIVITY PROFILE

Compound name	RRT (anthracene)	Minimum detectable conc. (pg/µℓ)
Naphthalene	0.562	660
Anthracene	1.00	11
Fluoranthene[a]	1.22	71
2-Methyl anthracene	1.45	74
Benz(a) anthracene[b]	1.77	0.80
Benzo(k)fluoranthene	2.41	0.081
Benzo(a)pyrene[c]	2.57	0.28
7,12-Dimethyl-[d] benzanthracene	2.88	0.67
1,2,5,6-Dibenzanthracene	3.05	0.57
Indeno(1,2,3-cd)pyrene	3.16	25
Benzo(ghi)perylene	3.32	0.91
Anthanthrene	3.07	1.0[e]
Coronene	4.62	0.15[f]

[a] Co-elutes with Pyrene.

[b] Co-elutes with Triphenylene and Chrysene.

[c] Co-elutes with Benzo(e)pyrene.

[d] Co-elutes with 1,2,3,4-Dibenzanthracene.

[e] Approximate.

[f] Using emission wavelength of 450 nm.

standard. All identifications were made from retention time data recorded relative to the internal standard. Quantitative data were calculated from calibration curves constructed for each of the PNA species. The PNA calibration mixture was injected daily as a check on column resolution and detector sensitivity. Chromatograms such as the one shown in Figure 15 were typical for each of the sample extracts analyzed.

TABLE 27. INSTRUMENT OPERATING CONDITIONS

HPLC		Fluoresence	
DuPont 850 HPLC w/ gradient elution		Perkin-Elmer 650-10S detector	
Column		Wavelength (nm)	
Zorbax ODS 25.0 cm x 4.7 cm		Excitation	300
		Emission	400
Flow rate		Slit width	15 nm
1.5 ml/min		Output	1 Volt to Spectra Physics Minigrator
Solvent	Methanol/Water		
Step Gradient			
% Methanol	Time (min)	Chart Speed	20 cm/hr
1. 80-85	20		
2. 85-90	15		
3. 90 - HOLD	10		
4. 90-95	10		
Oven Temperature	40°C		

BIOASSAY TECHNIQUES

The phased EA approach provides for specific chemical and biological tests. The chemical characterization of effluent or emission streams is necessary to define the need for and the possible type of control technology. However, the final objective of the IERL-RTP EA methodology is the control of industrial emissions that may cause biological harm. Testing of feed or waste streams for biological (health and ecological) effects is necessary both to provide a direct measure of toxicity as well as to complement the chemical data and ensure that the assessment is comprehensive.

A biological test regiment has, therefore, been developed to provide some indication of potential health or environmental hazard.[7,8] The Level 1 bioassay test scheme was created as an initial screening program. As such, the sensitivity and specificity of the tests prescribed are adequate only to

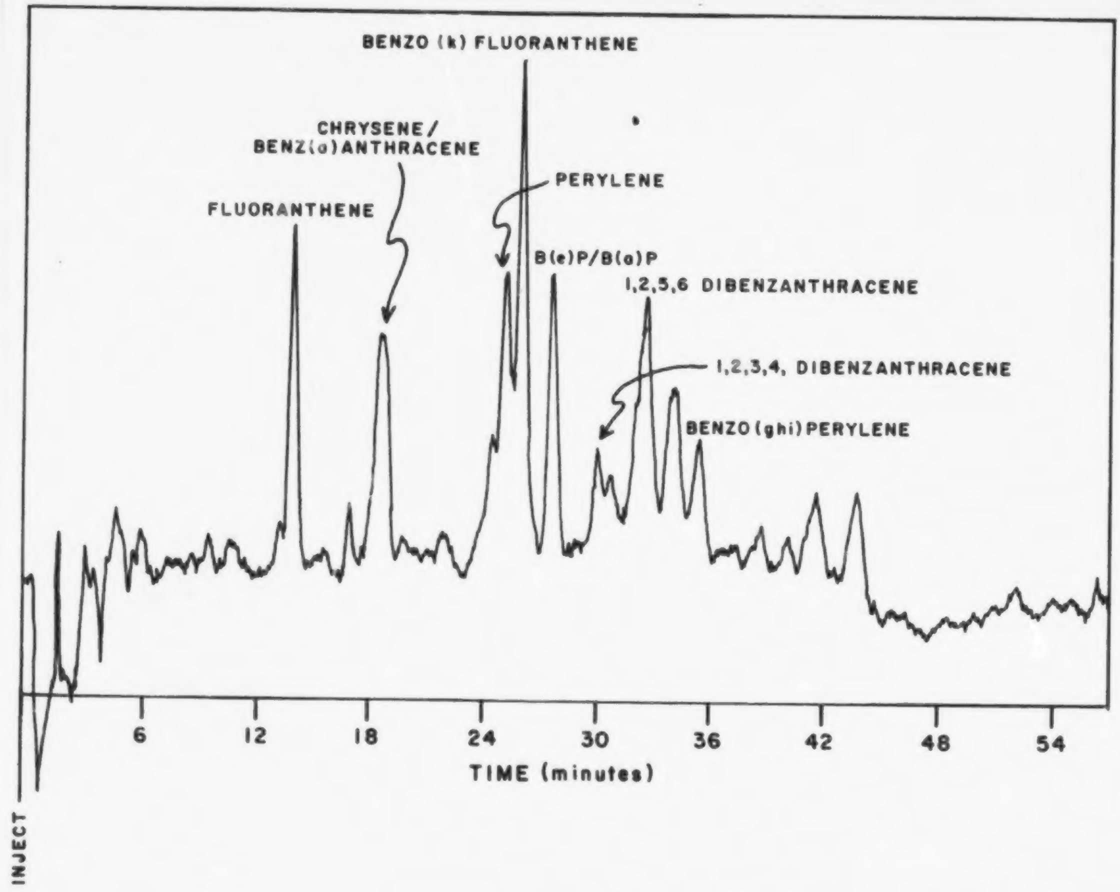


Figure 15. A typical chromatogram from HPLC/Fluorescence of Exxon sample stream extracts.

point out some of the more hazardous emission streams associated with the processes under study. Level 1 bioassays are outlined in Figure 16 for multimedia samples and are briefly described in Table 28. Detailed protocols for each Level 1 bioassay used in this test program are based on those in the Level Bioassay Manual.[7] These bioassay tests are outlined below.

Health Effects Tests

Microbial Mutagenesis (Ames Test)--

The Ames mammalian microsome mutagenicity test using Salmonella typhimurium is one of the primary health effects screening tests incorporated into Level 1 of the IERL-RTP Environmental Assessment methodology.

The Ames assay system is used to determine the ability of effluent stream samples to alter the genetic material of a bacterial cell; it is a genetically well-characterized system and has been rather extensively validated as a test for detection of gene mutation. A detailed protocol for routine use of the assay system was published by Ames and coworkers in 1975.[9] Since that time the assay system has gained wide acceptance and has been incorporated into testing regimes of both private industry and government agencies for a wide variety of samples.

The Ames assay system measures reverse mutations, both frame-shifts and base pair substitutions, in histidine-dependent strains of Salmonella that have been genetically engineered to increase their sensitivity and specificity. The tester strains are exposed to the test substance (mutagen) both in the presence and absence of mammalian metabolic activating enzymes. These enzymes convert many potential mutagens to their active form by mimicing in vivo conditions. The formation of bacterial colonies in a histidine-free medium after treatment is considered a criteria of the effectiveness of the test substance as a mutagen.

The Ames mammalian-microsome assay system is now extensively used as a primary screening test that is believed to provide a rapid, inexpensive method to pinpoint potentially carcinogenic substances to which man may be exposed. Based on the work of McCann et al.[10] and other investigators,[11-13] there appears to be a high correlation (85 to 90 percent) between those substances detected as mutagens in Salmonella typhimurium and carcinogenicity in mammals.

Level 1 criteria for a positive (mutagenic) response in the Ames test is a ratio of test revertants to control revertants greater than 2 for any tester strain (TA-1535, TA-1537, TA-1538, TA-98, or TA-100), plus an increasing dose/response relationship over three successive dose ranges. Also, the experimental response must be reproducible run to run. The experimental procedure is discussed in detail elsewhere.[3,8]

Cytotoxicity Assays (RAM and CHO)--

Level 1 cytotoxicity assays employ mammalian cell lines in culture to measure metabolic impairment and death resulting from in vitro exposure to toxicants. Rabbit alveolar macrophages (RAM) and Chinese hamster ovary (CHO) cells are the cell lines of choice.

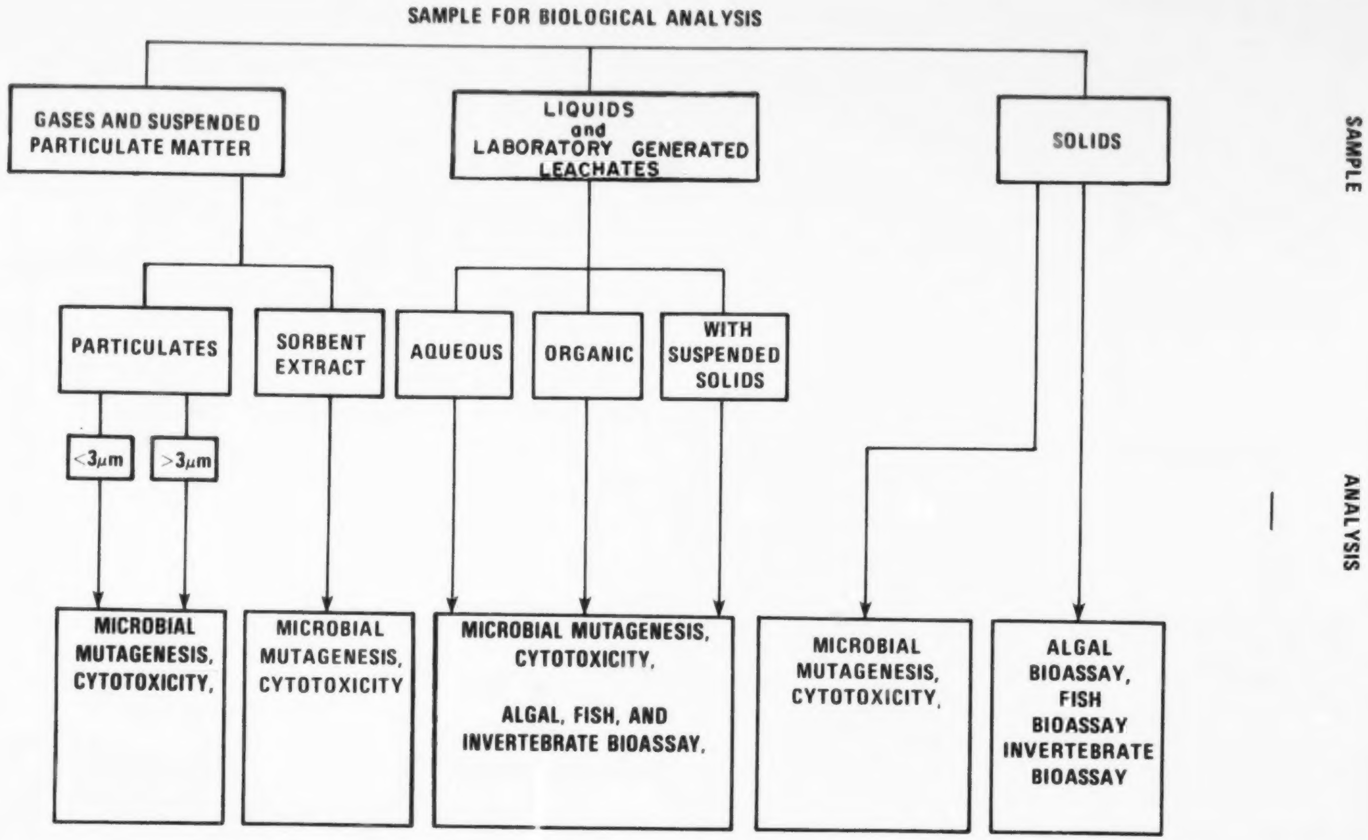

SAMPLE FOR BIOLOGICAL ANALYSIS
GASES AND SUSPENDED PARTICULATE MATTER
LIQUIDS and LABORATORY GENERATED LEACHATES
SOLIDS
PARTICULATES
SORBENT EXTRACT
AQUEOUS
ORGANIC
WITH SUSPENDED SOLIDS
<3μm
>3μm
MICROBIAL MUTAGENESIS, CYTOTOXICITY,
MICROBIAL MUTAGENESIS, CYTOTOXICITY
MICROBIAL MUTAGENESIS, CYTOTOXICITY,
ALGAL, FISH, AND INVERTEBRATE BIOASSAY,
MICROBIAL MUTAGENESIS, CYTOTOXICITY,
ALGAL BIOASSAY, FISH BIOASSAY INVERTEBRATE BIOASSAY
SAMPLE
ANALYSIS

Figure 16. Biological analysis overview.[7]

TABLE 28. LEVEL 1 SCREENING BIOASSAYS[7]

Test	Effect	Description	Test outputs
		Health Effects Tests	
Microbial mutagenesis (Ames test)	Mutagenesis	Genetically sensitive strains of microorganisms are exposed to various doses of sample with and without exogenous metabolic activation.	Mutagenic response is measured relative to controls.
Cytotoxicity	Cellular toxicity	Selected cells (RAM and CHO) are exposed to various doses of sample, then metabolic and other endpoints are measured.	An index of functional impairment, toxicity, and metabolic change is established relative to controls.
		Ecological Effects Tests	
Algal growth response	Algal Growth inhibition or promotion	Cultures of selected marine and/or freshwater algae are used to gauge reaction to sample or dilution thereof.	Growth response measure-stimulation or inhibition.
Aquatic animal exposure (static acute bioassay)	Animal toxicity	Select marine and/or freshwater vertebrates and invertebrates are exposed to a graded dilution series of samples	Gross index of toxic potential to representative animals.

The alveolar macrophage represents a central line of defense in the lung by virtue of its ability to engulf (phagocytize) and thus remove inhaled particles from the deep lung. This cell line is appropriate, therefore, to define the acute cellular toxicity of airborne particles and associated substances. Following exposure of the cells to the sample in vitro, four parameters are measured: total cell count, cell viability (assessed through trypan blue dye exclusion), total protein, and intracellular ATP concentration.[8]

Although cytotoxic response in the RAM assay is important, the relative cytotoxicity of samples to other cell systems is of interest as well. In Level 1 a toxicity assay using the aneuploid Chinese hamster ovary (CHO) cell line is now specified. This technique involves the plating of a specified number of cells on a tissue culture dish and subsequent exposure of the cells to the samples. Discrete "clonal" colonies of cells are allowed to grow. Plates are scored after this incubation period and relative plating efficiency is calculated. This plating efficiency may be plotted as a function of exposure concentration of test material and a value analogous to an LC_{50} may be calculated.[8]

The in vivo Rodent Acute Toxicity assay system is currently undergoing revision for Level 1 testing. At present, it appears mice will now be specified for testing in place of rats. This assay was not performed on Exxon samples.

Ecological Effects Tests

Although both freshwater and marine assays are specified for Level 1 use, only freshwater testing is relevant to assay of fluidized-bed combustion effluent samples. Discussion is, therefore, limited to these assays.

Freshwater Algal Assay--

The primary test alga in Level 1 is Selenastrum capricornutum. The test is designed to be used to quantify the biological response (algal growth) to changes in concentrations of nutrients and to determine whether or not various effluents are toxic or inhibitory to algae. These measurements are made by adding a selected test alga to the test water and determining algal growth at appropriate intervals. An EC_{50} corresponding to growth inhibition is calculated.[8]

Acute Static Aquatic Bioassays with Freshwater Fish and Daphnia--

The fathead minnow (Pimephales promelus) is the primary vertebrate used in all tests carried out under this protocol for the environmental assessment studies. The invertebrate choice is Daphnia magna, which should be used if additional toxicity data are desired or if it is impossible to use the fathead minnow. These representative aquatic organisms integrate synergistic and antagonistic effects of all the components in the aqueous test sample over the duration of their exposure. The test is scored by the number of dead or affected organisms after a specified period; i.e., every 24 hours after the beginning of the test. More frequent observations may be desirable, especially at the beginning of the test. Fathead minnow tests run for 96 hours; Daphnia tests run for 48 hours. An LC_{50} is calculated for fathead minnows. An EC_{50} is calculated for Daphnia. The effect used to determine the EC_{50} for Daphnia is immobilization, that is, lack of movement except for minor activity of appendages.

Terrestrial Ecology Tests--

Terrestrial bioassays have been developed relatively recently. Several assay systems are currently under review by IERL and their status is subject to change. Among the tests being considered for inclusion in the Level 1 bioassay test regimen are: a modified stress ethylene test designed for assessment of gaseous industrial emissions; a seedling germination test; and a short-term insect toxicity test employing Drosophila melanogaster. No terrestrial assays were included in this source test evaluation. Table 29 describes the bioassay test matrix for the Exxon Miniplant Environmental Assessment.

Samples were prepared and assays performed in accordance with the procedures specified in the Level 1 Bioassay Manual.[7] Bioassays were performed by Battelle-Columbus Laboratories.

TABLE 29. BIOASSAY TEST MATRIX FOR EXXON MINIPLANT LEVEL 1 ENVIRONMENTAL ASSESSMENT

Bioassay	ESP hopper catch	Regen. cyclone	Comb. bed	2^o cyclone	3^o cyclone	SASS part <3 μm	SASS part $\geq$3 μm	Part. filter cont.	Comb. XAD	Reg. XAD	XAD blank
Health effects tests											
Ames test	X	X	X	X	X	X	X	X	X	X	X
RAM	X	X	X	X	X	b	b	b			
CHO									X	X	X
Ecological effects tests											
Algal growth		X[a]	X	X	X						
Fish/*Daphnia*		X	X	X	X						

[a] Samples run in the algal growth and fish/*Daphnia* assays are leachate of the bulk solid samples.

[b] Sample size was not adequate to conduct RAM tests.

SECTION 5

TEST RESULTS

Test data were evaluated with the methodologies developed by IERL-RTP for their Environmental Assessment programs. If comparisons between and among sets of data from Environmental Assessment or other projects are to be of maximum benefit, such comparisons need to employ a standardized format. This format is provided by using a Source Analysis Model (SAM) coupled with the Multimedia Environmental Goal (MEG) methodology.

METHODOLOGIES

SAM/1A and the MEG Methodology

The MEG methodology[14] provides a means of summarizing health and ecological effects data. The MEG chart, as depicted in Figure 17, provides a workable system for evaluating discharged pollutants for the purpose of environmental assessment.

The MEG format can aid in evaluation of current environmental background for a pollutant and can help in environmental objectives development as well as in selection and application of assessment alternatives. This latter function of the MEG methodology is accomplished by establishing emission goals (specifically, Discharge Multimedia Environmental Goals (DMEGs). DMEGs are derived from a series of models which employ experimental toxicity data or existing Federal or other standards and criteria, specific for each pollutant for which a MEG chart has been formulated. Comparison of the discharged concentration of a pollutant species from a source with its DMEG provides decision criteria for further environmental data acquisition (that is, a "trigger" to go from Level 1 to a Level 2 analytical effort), as well as a means of environmental alternatives analysis when the DMEGs are used in conjunction with a SAM. Through the use of this model, effluent or emission streams may be ranked by potential toxicity to man or the environment. This assessment of priorities is important in deciding if and to what extent further, more intensive, sampling and analysis is required and it can help determine the need, and in some cases the design, of appropriate control technology.

Level 1 survey results are assessed in terms of MEG compound categories and the individual DMEG values corresponding to each individual pollutant species. These values are incorporated into Source Analysis Model/1A (SAM/1A).[15] SAM/1A establishes a degree of hazard (called Discharge Severity (DS)) for each substance within an effluent stream as well as a value for the

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MULTIMEDIA ENVIRONMENTAL GOALS

EMISSION LEVEL GOALS							
	I. Based on Best Technology		II. Based on Ambient Factors				
Category	A. Existing Standards	B. Developing Technology	A. Discharge Multimedia Environ. Goal		B. Ambient Level Goal*		C. Elimination of Discharge
	NSPS, BPT, BAT	Engineering Estimates (R&D Goals)	Based on Health Effects	Based on Ecological Effects	Based on Health Effects	Based on Ecological Effects	Natural Background*
Air, $\mu g/m^3$ (ppm Vol)							
Water, $\mu g/l$ (ppm Wt)							
Land, $\mu g/g$ (ppm Wt)							

*To be multiplied by dilution factor

	AMBIENT LEVEL GOALS				
	I. Current or Proposed Ambient Standards or Criteria		II. Toxicity Based Estimated Permissible Concentration		III. Zero Threshold Pollutants Estimated Permissible Concentration
	A. Based on Health Effects	B. Based on Ecological Effects	A. Based on Health Effects	B. Based on Ecological Effects	Based on Health Effects
Air, $\mu g/m^3$ (ppm Vol)					
Water, $\mu g/l$ (ppm Wt)					
Land, $\mu g/g$ (ppm Wt)					

Figure 17. Current version of the MEG chart.

total stream, thus providing a mechanism for ranking streams by potential hazard as mentioned above. A degree of hazard may be established to reflect both human health and the ecological domain.

SAM/1A is a model which provides a rapid screening technique for assessing the pollution potential of multimedia process or waste streams. There are a number of simplifying assumptions implicit in the use of SAM/1A.

- Only pollutant species for which a DMEG value has been derived need be considered when assessing a pollutant stream. It is also assumed that the DMEG values are adequate for estimating acute toxicity.
- Effluent streams from any process to which the model is applied are assumed not to interact with the external environment. That is, transport of the components in the effluent stream to the external environment occurs without chemical or physical transformation of those components.
- Although no assumption is made about pollutant dispersion, it is implied within the context of the model that such dispersion from the source would, in almost all cases, be equal to or greater than the safety factors normally applied to acute toxicity data to convert them to estimated safe chronic exposure levels.

These assumptions, along with the limited target accuracy of Level 1 test data and assumptions made in developing the DMEG values (see Reference 14) have to be considered when interpreting test results using SAM/1A. It is worth emphasizing that the weighted DS sums, by which streams are ranked by "toxicity" using SAM/1A, are only useful within the context of the model and should not be misconstrued as representing a true numerical or other measure of potential toxicity to human health or the environment.

The basic steps included in SAM/1A are:

- Determination of the specific pollutant species to be considered in each effluent stream under study and the concentration of such species within the stream (from Level 1 analytical data).
- Pollutant concentrations are divided by the DMEG value specific for that species to determine DS. DS values are indicative of the contribution of each specific pollutant within the stream to the total calculated hazard factor representative of that stream.
- The product of the DS for each species within the stream and the stream flow rate is designated Weighted Discharge Severity (WDS).
- The total effluent stream DS is calculated by summing all of the individual DS values for substances in that stream. Also, the total stream WDS is calculated by summing the individual pollutant

> WDS. These resulting dimensionless sums may be used to compare emission or effluent streams within a facility or among facilities. When WDS sums are calculated for all streams exiting a facility, and totaled, this value may then be used to compare calculated total degrees of hazard representing other facilities or other processes. In this manner, sources may be ranked according to the levels of potentially toxic substances in their effluent discharges.

To illustrate how SAM/1A is implemented, a portion of a Level 1 SAM/1A worksheet is depicted in Figure 18. This worksheet provides an easy means to show the derivation of DS and WDS sums.

As shown in Figure 18, problem pollutants within a stream are readily identified by the relatively large ratio of their emission-to-goal concentrations. Any stream having pollutants which are thus identified ("flagged") by having a DS value greater than unity would probably be designated for further study. This is an important point because Level 1 sampling procedures are primarily screening techniques. By using the SAM/1A-DMEG model, problem streams and problem pollutants are assured of being addressed first by further sampling and analysis programs.

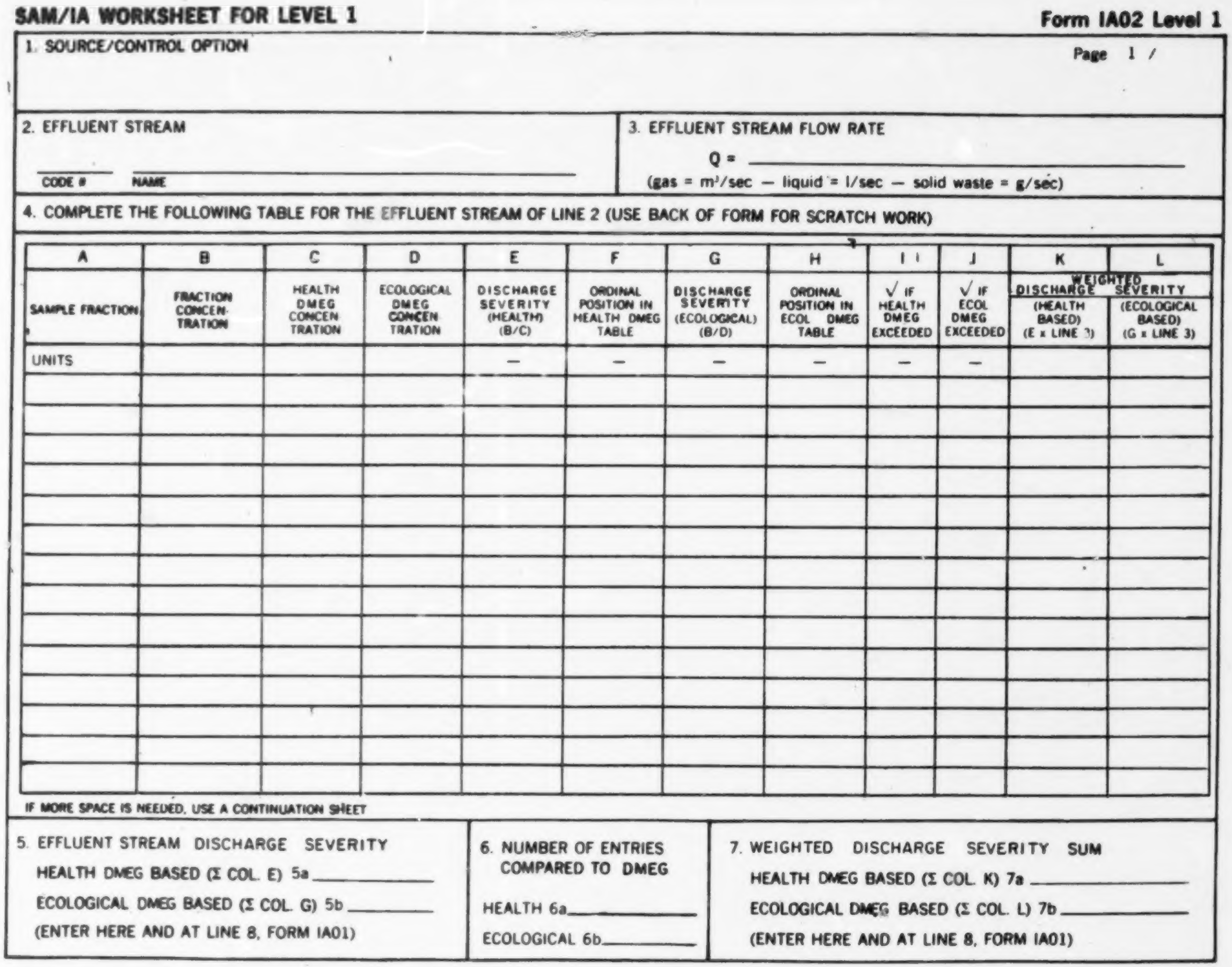
Rather than use the worksheets specified for SAM/1A and do the necessary calculations manually, GCA has developed a computer program which implements the SAM/1A model. PTSAM1A is a FORTRAN source analysis model which compares observed discharge concentrations of measured pollutants with DMEG values, both health-and ecological-based, and computes those ratios and sums generated by SAM/1A. Results from SAM/1A analysis of Exxon samples are presented in Appendix B as computer printout.

Bioassay Data Analysis

Bioassay test results are characterized according to the degree of response defined using the criteria that have been established by IERL-RTP for Level 1 bioassays. These criteria are listed in Table 30. These bioassay test results are included with SAM/1A analysis of the chemical data and aid in ranking the streams analyzed at Exxon by order of priority for further testing. Where possible, bioassay data are compared to chemical data in an attempt to discern the identity of the toxic species causing a positive bioassay test response.

Analysis and Interpretation of Exxon Data

Data generated from Level 1 analyses of Exxon samples are of three types: inorganic analysis relying upon spark source mass spectroscopy, atomic absorption spectrometry, or wet chemical techniques; organic analysis using gravimetry, liquid chromatographic separation, infrared spectrophotometry, or low-resolution mass spectrometry (and onsite gas chromatography for gaseous streams); and bioassay results of specific health or ecological effects testing. Ideally, the chemical data, both inorganic and organic, should be melded together within the framework of the DMEG/SAM/1A methodology and this analysis



SAM/IA WORKSHEET FOR LEVEL 1 **Form IA02 Level 1**

1. SOURCE/CONTROL OPTION

Page 1 /

2. EFFLUENT STREAM

________ ______________________________

CODE # NAME

3. EFFLUENT STREAM FLOW RATE

Q = ____________________________

(gas = m³/sec — liquid = l/sec — solid waste = g/sec)

4. COMPLETE THE FOLLOWING TABLE FOR THE EFFLUENT STREAM OF LINE 2 (USE BACK OF FORM FOR SCRATCH WORK)

A	B	C	D	E	F	G	H	I	J	K	L
										WEIGHTED DISCHARGE SEVERITY	
SAMPLE FRACTION	FRACTION CONCENTRATION	HEALTH DMEG CONCENTRATION	ECOLOGICAL DMEG CONCENTRATION	DISCHARGE SEVERITY (HEALTH) (B/C)	ORDINAL POSITION IN HEALTH DMEG TABLE	DISCHARGE SEVERITY (ECOLOGICAL) (B/D)	ORDINAL POSITION IN ECOL DMEG TABLE	√ IF HEALTH DMEG EXCEEDED	√ IF ECOL DMEG EXCEEDED	(HEALTH BASED) (E x LINE 3)	(ECOLOGICAL BASED) (G x LINE 3)
UNITS				—	—	—	—	—	—		

IF MORE SPACE IS NEEDED, USE A CONTINUATION SHEET

5. EFFLUENT STREAM DISCHARGE SEVERITY

HEALTH DMEG BASED (Σ COL. E) 5a __________

ECOLOGICAL DMEG BASED (Σ COL. G) 5b __________

(ENTER HERE AND AT LINE 8, FORM IA01)

6. NUMBER OF ENTRIES COMPARED TO DMEG

HEALTH 6a __________

ECOLOGICAL 6b __________

7. WEIGHTED DISCHARGE SEVERITY SUM

HEALTH DMEG BASED (Σ COL. K) 7a __________

ECOLOGICAL DMEG BASED (Σ COL. L) 7b __________

(ENTER HERE AND AT LINE 8, FORM IA01)

Figure 18. SAM/1A worksheet, level 1.[2]

TABLE 30. RESPONSE RANGES FOR RANKING OF VARIOUS BIOTESTS[8]

Assay	Activity measured	MAD	Response ranges High	 Moderate	 Low	 Not detectable
Health Tests						
Ames	Mutagenesis	5 mg/plate or 500 μL/plate	<0.05 mg or <5 μL	0.05–0.5 mg or 5–50 μL	0.5–5 mg or 50–500 μL	ND at >5 mg or ND at >500
RAM, CHO	Lethality (LC_{50})	1,000 μg/mL or 600 μL/mL	<10 μg or <6 μL	10–100 μg or 6–60 μL	100–1,000 μg or 60–600 μL	LC_{50}>1,000 μg or LC_{50}>600 μL
Ecological Tests						
Algae	Growth Inhibition (EC_{50})	1,000 mg/L or 100%	20% or 200 mg	20–75% or 200–750 mg	75–100% or 750–1,000 mg	EC_{50} 100% or EC_{50} 1,000 mg
Fish	Lethality (LC_{50})	1,000 mg/L or 100%	<20% or <200 mg	20–75% or 200–750 mg	75–100% or 750–1,000 mg	LC_{50}>100% or LC_{50}>1,000 mg
Invertebrate	Lethality (LC_{50})	1,000 mg/L or 100%	<20% or <200 mg	20–75% or 200–750 mg	75–100% or 750–1,000 mg	LC_{50}>100% or LC_{50}>1,000 mg

MAD = Maximum Applicable Dose (Technical Limitations).

LD_{50} = Calculated Dosage Expected to Kill 50% of Population.

LC_{50} = Calculated Concentration Expected to Kill 50% of Population.

EC_{50} = Calculated Concentration Expected to Produce Effect in 50% of Population.

ND = Not Detectable.

should provide a means of selection of those streams requiring further, more intensive Level 2 analyses. Unfortunately, the SAM/1A model could not be implemented to the extent described above. Samples analyzed from the Exxon Miniplant generally contained such low levels of organic compounds that inclusion of these data into the SAM/1A format was not practicable. Therefore, SAM/1A was only used to flag those inorganic trace elements which exceeded their respective DMEG. Organic data were interpreted in the following manner:

- Initial Level 1 organic data were compiled. These data included totals for volatile species (TCO — Total Chromatographable Organics), nonvolatile species (GRAV — Gravimetric), and onsite GC spectra where applicable. Such values were represented as $\mu g/g$ or $\mu g/m^3$, depending on the emission goal (DMEG) to be applied.

- A survey was made of all DMEG values that have been adopted for organic compounds or classes of compounds (586 to date).[16]

- The assumption was made that the total weight of organics present in the sample analyzed was representative of one compound, as a worst case, and all species whose DMEG was lower than this total were listed. This exercise resulted (for some samples) in a list of compounds of potential concern. In other samples, this listing resulted in elimination of organic compounds as an area of concern for future investigation.

- Organic compounds of concern were then reviewed based on knowledge of process chemistry, operating conditions, and the available Level 1 bioassay results. This review enabled elimination of some species which could not possibly be present in these FBC emission streams.

- A final list (on a stream-by-stream basis) of organic compounds of potential concern was compiled.

The resulting three sets of data from Level 1 analysis for each tested stream from the Exxon Miniplant PFBC were compared. Inorganic species which were flagged by SAM/1A as exceeding one of their emission goals, organic species of potential concern possibly present in a sample (as determined above), and the response of a sample in the Level 1 battery of biological tests were all considered in making final evaluation of which streams should first receive Level 2 analysis.

INORGANIC ANALYTIC RESULTS

Gaseous Waste Streams

A major effort of the source test evaluation involves sampling and analysis of gaseous emission streams. At Exxon, the two gaseous streams of interest were the Combustor Flue Gas (stream sampling site 1 in Figure 2) and the Regenerator Flue Gas (site 3 in Figure 2). Results are reported here for the diluted combustor flue gas because this represents the true emission stream;

also, particles entrained in the flue gas were only collected for the diluted stream. No inorganics are assumed to be contributed by the dilution air. Data for the undiluted flue gas are reported in Appendix B. It must be emphasized when considering data from the regenerator off-gas that this stream would undergo subsequent treatment and not be vented directly to the ambient environment.

Samples were obtained using the SASS train for both streams (see Section 3). Inorganic analyses included spark source mass spectroscopy (SSMS) for trace elements and atomic absorption spectrometry (AA) for mercury and antimony (see Section 4). Table 18 summarizes the results of analysis for trace elements in flue gas samples. The reported results represent the concentrations measured in the total catch (obtained using the SASS train). No attempt was made to differentiate concentrations of trace elements by particle size. Data for size-fractionated particles are reported in Appendix B.

Measured concentrations were compared to their respective emission goals, the health-based air DMEG. DS ratios greater than 1.0 indicate those species which exceeded their emission goals.

Table 31 indicates that chromium, nickel, and rhodium exceed their health emission goals in the regenerator flue gas stream. Phosphorus, chromium, iron, nickel, arsenic, and barium were flagged in the combustor flue gas stream. Although not presented in Table 31, vanadium was observed to exceed its discharge goal, in each flue gas stream, when ecological goals were considered. Vanadium was the only species to exceed its ecological DMEG. Flagging of these elements is indicative of areas of potential Level 2 investigation.

Although four inorganic species exceeded their air health or ecological DMEG in the regenerator flue gas, further analyses of this stream are unlikely. Regenerator flue gas would receive treatment prior to venting to the environment and thus does not represent a true emission stream. Therefore, any Level 2 inorganic investigations would be based on those elements in combustor flue gas which exceeded their emission goals.

As an initial effort, an assessment must be made of the quality and validity of the Level 1 data for each element that exceeds its emission goal.

Phosphorus - the stringent emission goal for phosphorus is derived based on toxicity data for elemental phosphorus. Obviously, it is not this species which is present in Exxon combustor flue gas but rather phosphorus in a less toxic and less reactive form. Level 2 efforts will not include any further investigation of this element.

Barium - barium exceeds its air, health DMEG when its concentration, measured by SSMS, is assumed maximized within a range of values which were obtained when SASS train samples were analyzed. When SSMS data for SASS train components (see Appendix B) is reviewed, barium concentration is listed as

TABLE 31. SAM/1A ANALYSIS OF TRACE ELEMENT CONCENTRATIONS IN EXXON GASEOUS WASTE STREAMS.

Pollutant species	Emission goal health-based air DMEG ($\mu g/m^3$)	Regenerator flue gas (EX 1-1-03) total SASS-train catch		Combustor flue gas (EX 1-3-01) total SASS-train catch	
		Discharge concentration ($\mu g/m^3$)	Discharge severity (conc./DMEG)	Discharge concentration ($\mu g/m^3$)	Discharge severity (conc./DMEC)
Lithium	22	0.1	4.5×10^{-3}	5.3	0.24
Beryllium	2	0.3	0.15	0.6	0.30
Boron	3,100	7.0	2.3×10^{-3}	1,800	0.58
Sodium	53,000	30	5.7×10^{-4}	47	8.9×10^{-4}
Magnesium	6,000	52	8.7×10^{-3}	320	5.3×10^{-2}
Aluminum	5,200	173	3.3×10^{-2}	380	7.3×10^{-2}
Silicon	10,000	100	1.0×10^{-2}	1100	0.11
Phosphorus	100	22	0.22	130	1.3
Sulfur	N*	13×10^3	N	1.0×10^4	N
Potassium	N	46	N	250	N
Calcium	16,000	360	2.3×10^{-2}	5.0×10^3	0.31
Titanium	6,000	6.4	1.1×10^{-3}	560	9.3×10^{-2}
Vanadium†	500	2.3	4.6×10^{-3}	31	6.2×10^{-2}
Chromium	1	110	110	670	670
Manganese	5,000	16	3.2×10^{-3}	60	1.2×10^{-2}
Iron	1,000	380	0.38	3.6×10^3	3.6
Cobalt	50	7.1	0.14	6.3	0.13
Nickel	15	233	16	400	27
Copper	200	69	0.35	8.0	4.0×10^{-2}
Zinc	4,000	27	6.8×10^{-3}	1,000	0.25
Gallium	5,000	0.1	2.0×10^{-5}	3.6	7.2×10^{-4}
Germanium	560	0.3	5.4×10^{-4}	0.8	1.4×10^{-3}
Arsenic	2	1.6	0.80	4.2	2.1
Selenium	200	9.9	5.0×10^{-2}	15	7.5×10^{-2}
Rubidium	120,000	0.2	1.7×10^{-6}	4.8	4.0×10^{-5}
Strontium	3,100	2.0	6.5×10^{-4}	130	4.2×10^{-2}
Yttrium	1,000	0.2	2.0×10^{-4}	1.5	1.5×10^{-3}
Zirconium	5,000	1.9	3.8×10^{-4}	36	7.2×10^{-3}
Niobium	22,000	0.5	2.3×10^{-5}	3.3	1.5×10^{-4}
Molybdenum	5,000	25	5.0×10^{-3}	16	3.2×10^{-3}
Ruthenium	N	1.2	N	0.4	N
Rhodium	1	2.7	2.7	0.1	0.10
Palladium	N	<1.2	N	0.3	N
Cadmium	10	0.9	9.0×10^{-2}	1.4	0.14
Tin	N	16	N	2.7	N
Tellurium	100	2.6	2.6×10^{-2}	0.3	$3.0 \times 10^{-}$

(continued)

TABLE 31 (continued)

Pollutant species	Emission goal health-based air DMEG ($\mu g/m^3$)	Regenerator flue gas (EX-1-1-03) total SASS-train catch		Combustor flue gas (EX 1-3-01) total SASS-train catch	
		Discharge concentration ($\mu g/m^3$)	Discharge severity (conc./DMEG)	Discharge concentration ($\mu g/m^3$)	Discharge severity (conc./DMEG)
Iodine	N	2.6	N	1.6	N
Cesium	82,000	<0.1	1.2×10^{-6}	0.2	2.4×10^{-6}
Barium	500	4.9	9.8×10^{-3}	1,300	2.6
Lanthanum	110,000	0.5	4.5×10^{-6}	16	1.5×10^{-4}
Cerium	37,000	0.5	1.4×10^{-5}	15	4.1×10^{-4}
Praseodymium	51,000	<0.4	$<7.8 \times 10^{-6}$	1.3	2.5×10^{-5}
Neodymium	N	2.1	N	6.1	N
Samarium	53,000	<1.7	$<3.2 \times 10^{-5}$	1.3	2.5×10^{-5}
Europium	N	<0.4	N	0.3	N
Gadolinium	N	<0.9	N	0.5	N
Terbium	N	<0.3	N	0.4	N
Dysprosium	9,300	<1.0	$<1.1 \times 10^{-4}$	0.8	8.6×10^{-5}
Holmium	N	<0.5	N	0.1	N
Erbium	N	<1.7	N	0.9	N
Thulium	N	<0.6	N	<0.1	N
Ytterbium	1,000	<0.9	$<9.0 \times 10^{-4}$	0.5	5.0×10^{-4}
Lutetium	N	<0.6	N	0.1	N
Haffnium	500	<2.7	$<5.4 \times 10^{-3}$	0.4	8.0×10^{-4}
Tungsten	1,000	<2.2	$<2.2 \times 10^{-3}$	0.4	4.0×10^{-4}
Rhenium	N	<1.6	N	0.4	N
Osmium	N	<2.6	N	0.7	N
Iridium	N	<2.4	N	<0.7	N
Gold	N	<1.5	N	<0.4	N
Thallium	100	<1.2	$<1.2 \times 10^{-2}$	9.5	9.5×10^{-2}
Lead	150	7.9	5.3×10^{-2}	7.9	5.3×10^{-2}
Bismuth	410	<0.9	$<2.2 \times 10^{-3}$	0.2	4.9×10^{-4}
Thorium	420	<3.0	$<7.1 \times 10^{-3}$	3.2	7.6×10^{-3}
Uranium	9	<2.1	$<2.3 \times 10^{-3}$	0.5	5.6×10^{-2}
Mercury‡	50	<2.9	$<5.8 \times 10^{-2}$	<2.9	$<5.8 \times 10^{-2}$
Antimony‡	500	0.6	1.2×10^{-3}	0.2	4.0×10^{-4}

◯ indicates those species which exceeded their air, health-based DMEG value.

*N indicates no goal has been set, no discharge severity can be calculated.

†Vanadium exceeded its air, ecological-based DMEG value in both streams sampled (see data in Appendix B).

‡Concentrations of mercury and antimony were determined by atomic absorption spectrometry, all other elemental concentrations were measured by spark source mass spectroscopy.

between 55 and 1300 μg/m^3. Considering the large influence of the filter catch (<42 mg) towards these totals, barium data may be suspect. An initial Level 2 effort could involve verification of barium concentration by retesting SASS train component samples. Should high barium levels be verified, a determination of which barium species are present should be made. The DMEG for barium (500 μg/m^3) is based on soluble barium salts which are highly toxic when ingested, while insoluble compounds are generally non-toxic.

Chromium, Iron, and Nickel - These three elements should be considered together for possible Level 2 investigation. Review of SASS train SSMS data reveals that the major portion of each of these elements was contributed by the Composite sample. This sample consists, to a large extent, of the XAD module condensate which is in intimate contact with stainless steel. It is highly probable that the high levels of these three elements are due to contamination of the composite sample by the sampling train. Initial Level 2 efforts should be directed at determing, if possible, whether this contamination took place. If not practical, verification of concentrations observed should be obtained by retesting SASS train samples. These efforts should concentrate on chromium and nickel, which are more toxic than iron.

Chromium compounds occur principally as chromites (CrO_2^-). Other compounds include chromous (Cr^{+2}), chromic (Cr^{+3}), and hexavalent chromium as (CrO_2^{+2}). All chromium compounds are considered potentially toxic; hexavalent chromium is generally considered more hazardous than the trivalent form. Chromium (VI) is the subject of a NIOSH Criteria Document whose recommendations form the basis for the air health DMEG value of 1 μg/m^3. As a Level 2 effort, the concentration of chromium must be more accurately determined and the proportion of Cr^{+6}/total chromium must be quantified so a true measure of hazard may be obtained. Should Cr^{+6} be a minor constituent in the total chromium present, a new DMEG value may be employed based on one of the TLV values for less toxic chromium species.

Similar to chromium compounds, nickel exists in several oxidation states. The air health DMEG is based on the NIOSH recommendation of 15 μg/m^3 as Ni; this is equivalent to 43 μg/m^3 nickel carbonyl. The NIOSH recommendation does not, unlike that for chromium, differentiate hazard based on oxidation state. Rather, as shown, a difference is observed for inorganic versus organically bound nickel. Level 2 efforts must be directed toward quantification of organic/total nickel so true assessment of hazard may be made in a manner analogous to incorporating the different oxidation states present for Cr.

Arsenic - arsenic is a toxic element and combustor flue gas should be subjected to Level 2 investigation to better quantify arsenic levels. Following verification of arsenic concentrations by retest, efforts should be directed towards speciation of arsenic components. The toxicity of arsenic varies, as does chromium, with oxidation state with the trivalent state being the most toxic. The proportion of As^{+3}/total As should be quantified.

Vanadium - Vanadium in both flue gas samples exceeds its air ecological DMEG. This DMEG value is quite sensitive (1.0) and represents a value reported to produce noticeable effects to plants. Similar to the other species discussed, vanadium concentration should be quantified more accurately in all samples and oxidation states be determined. This is especially important if toxicity to plants should prove to depend on specific vanadium compounds.

Gaseous Streams--Results of Onsite Analyses--

The regenerator flue gas stream and the undiluted combustor flue gas stream were sampled (see Section 3) and analyzed (see Section 4) for certain gaseous inorganic and organic species.

Results of the analyses for ammonia and cyanide are presented in Table 32. The values listed represent the results of analysis of the respective impinger solution (in μg) divided by the volume of flue gas sampled (corrected to standard temperature and pressure). Results are reported for samples collected during two test runs.

TABLE 32. RESULTS OF FLUE GAS ANALYSIS FOR AMMONIA AND CYANIDE.

Test number	Sample	NH_3 ($\mu g/m^3$)	CN^- ($\mu g/m^3$)
EX 1-1-03	Regenerator flue gas	28,580	<10
EX 1-2-03	Regenerator flue gas	36,290	<10
EX 1-1-02	Undiluted combination flue gas	240	<10
EX 1-2-02	Undiluted combination flue gas	80	<10
DMEG ($\mu g/m^3$)	health	18,000	11,000
	ecological	350	34,000

As seen in Table 32, regenerator flue gas exceeds both emission goals for ammonia in both tests, combustor flue gas exceeds neither. Cyanide is below its DMEGs in all tests. Since regenerator flue gas is not an emission stream, further investigation in this area is not significant or required.

As reported in Section 3, data for sulfur species were provided by Exxon to GCA. Data are listed in Table 33 and compared to DMEG values where applicable.

Regenerator flue gas exceeds emission goals for sulfur oxides (as SO_2), hydrogen sulfide, and carbon disulfide. Since regenerator flue gas will be treated to remove sulfur prior to final venting to the atmosphere, these levels should be reduced.

SO_2 levels in undiluted combustor flue gas are slightly above DMEG limits. However, these SO_2 emissions, equivalent to 0.15 lb $SO_2/10^6$ Btu, are well below New Source Performance Standards for utility boilers (0.6 lb $SO_2/10^6$ Btu*, see Federal Register Vol. 44 No. 113, June 11, 1979).

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*This NSPS corresponds to 75 percent control based on 1.6%S, 13,500 Btu/lb coal.

TABLE 33. SULFUR FLUE GAS ANALYSES

Stream	Sulfur species (μg/m^3)				
	SO_2	H_2S	CS_2	COS	RSH (ppm)
Regenerator flue gas (EX 1-1-03)	9.1×10^6	1.1×10^5	3.1×10^5	5.3×10^4	<0.1
Regenerator flue gas (EX 1-2-03)	7.8×10^6	1.6×10^5	3.4×10^5	6.1×10^4	<0.1
Undil. comb. flue gas (EX 1-1-02)	5.2×10^4	$<1.4 \times 10^2$	$<1.6 \times 10^3$	$<2.0 \times 10^2$	<0.1
Undil. comb. flue gas (EX 1-2-02)	5.2×10^4	$<1.4 \times 10^2$	$<1.6 \times 10^3$	$<2.0 \times 10^2$	<0.1
Air DMEG[a] (μg/m^3)	1.3×10^4	2.3×10^4	6.0×10^4	4.4×10^5	-

[a] Health-based, no ecological air goals have been set.

Flue gas streams were also analyzed for fixed inorganic gases. These results are presented in Table 34.

TABLE 34. INORGANIC FIXED GAS ANALYSIS FOR FLUE GAS STREAMS

Flue gas stream analyzed	Fixed gas analyses[a]			
	CO_2	O_2	CO	NO_x
Regenerator (stream 3)	18.2	1.9	0.26	-
Undiluted, combustor (stream 2)	10.6	8.7	8 (ppmv)	52.8 (ppmv)

[a] Values are in percent (v/v) unless otherwise indicated.

No DMEG has been adopted for NO_x emissions. NO_x levels in undiluted combustor flue gas, equivalent to 0.09 lb $NO_x/10^6$ Btu, are well below current relevant New Source Performance Standards for utility boilers (0.6 lb $NO_x/10^6$ Btu).

Grab samples of flue gas streams were analyzed for gaseous hydrocarbons using a gas chromatograph with flame ionization detector (see Section 4).

Resulting peak retention times and areas were compared against a standard gas mixture for qualitative and quantitative analysis. Peaks are classified as GC group based on a boiling point reference as shown in Table 35.

TABLE 35. LEVEL 1 BOILING POINT RANGES

Level 1 designation	bp range (°C)	Hydrocarbon	bp (°C)
GC1	-160 to -100	Methane, C_1	-161
GC2	-100 to 50	Ethane, C_2	-88
GC3	-50 to 0	Propane, C_3	-42
GC4	0 to 30	Butane, C_4	0
GC5	30 to 60	Pentane, C_5	36
GC6	60 to 90	Hexane, C_6	69
GC7	90 to 100	Heptane, C_7	96

Results of this sampling and analysis are listed in Table 36.

Solid Waste Streams

The bulk solid waste streams from the Exxon Miniplant PFBC were chemically evaluated in two ways. Solid samples were analyzed for trace elements by SSMS (AA for Hg and Sb) and compared to land DMEG emission goals. DS was calculated for each. In addition to this, distilled water leachates were prepared (see Section 4). These leachates were analyzed in a similar manner and the results compared to water DMEGs. Results are summarized in Table 37. Complete SAM/1A analysis data may be found in Appendix B.

TABLE 36. ONSITE GAS CHROMATOGRAPHY ANALYSIS

Flue gas stream	Test No.	GC1 (ppmv)	GC2 (ppmv)	GC3 (ppmv)	GC4 (ppmv)	GC5 (ppmv)	GC6 (ppmv)	GC7 (ppmv)
Diluted combustor	3	272	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Undiluted combustor	1	0.8	<0.1	<0.1	0.7	<0.1	<0.1	<0.1
Undiluted combustor	2	3.5	<0.1	<0.1	0.5	<0.1	<0.1	<0.1
Regenerator	1	196	<0.1	<0.1[a]	3.0	<0.1	<0.1	<0.1
Regenerator	2	1360	<0.1	<0.1	<0.1[a]	<0.1	<0.1	<0.1
Regenerator	3	940	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

[a] Peak visible but not quantifiable.

As seen in Table 37, numerous, albeit similar, trace elements exceeded their respective land DMEG values in all particles collected by the various control devices employed at Exxon. Only four elements exceeded one or both land DMEGs for Spent Combustor Bed Material.

When laboratory leachates of these bulk solid materials were prepared and analyzed, however, no element in any sample exceeded any discharge goal. In fact, most elemental concentrations in the leachates were more than two orders of magnitude below their goals.

These contradictory results make evaluation of solid waste streams difficult. In each case the discharge goals employed for comparison with elemental concentrations in the sample are meant to provide a means of assessing a potential health or environmental hazard due to worst-case leaching of a bulk solid residue relegated to a landfill or other disposal area. We have assumed that analysis of the laboratory-generated leachate and comparison with water DMEGs provides a truer measure of the potential hazards associated with the leaching of Exxon bulk solid waste streams than does comparison of solids data with land DMEGs. Based on these data, leaching of potentially toxic species from disposed solid waste streams at Exxon would not appear to be a problem. Solid waste streams would, therefore, be at a lower priority for subsequent Level 2 analysis than would flue gas particles.

Laboratory-generated leachates were also analyzed for various anions using Ion Chromatography (see Section 4). Results are presented in Table 38.

No DMEG values have been adopted for these inorganic species, however, the concentrations reported in Table 38 may be compared with those anions addressed by EPA National Primary and Secondary Drinking Water Regulations. Comparison between anion concentrations and drinking water goals is presented in Table 39.

TABLE 37. SUMMARY OF SAM/1A ANALYSIS OF EXXON SOLID WASTE STREAMS AND LABORATORY - GENERATED DISTILLED WATER LEACHATES

Sample number and description	Chemical species which exceeded their land DMEG[a]		Chemical species which exceeded their water DMEG[b]	
	Health	Ecological	Health	Ecological
EX 1-1-05-FAR Regenerator Cyclone Catch	Be,Ca,Cr,Mn,Fe,Ni,As	Be,Al,P,Ca,Ti,V,Cr,Mn,Fe,Ni,Cu Zn,As,Cd	None[d]	None
EX 1-1-06-CB Spent Combustor Bed Material	Ca,Fe	Ca,P,Fe,Ni	None	None
EX 1-1-07-FA2 Second Cyclone Catch	Ca,Cr,Mn,Fe,Ni,As,Pb	Al,P,Ca,Ti,V,Cr,Mn,Fe,Ni,Cu, Zn,As,Cd,Pb	None	None
EX 1-1-08-FA3 Third Cyclone Catch	Ca,Cr,Mn,Fe,Ni,As,Pb	Al,P,Ca,Ti,V,Cr,Mn,Fe,Ni,Cu, Zn,As,Se,Cd,Pb	None	None
EX 1-1-09-CF Coal Feed	Not Evaluated[c]	Not Evaluated	None	None
EX 1-1-10-SF Sorbent Feed	Not Evaluated	Not Evaluated	None	None
EX 1-3-01-FA ESP Hopper Catch	Cr,Mn,Fe,Ni,As,Se,Pb	Al,P,Ca,Ti,V,Cr,Mn,Fe,Ni,Cu, Zn,As,Se,Cd,Ba,Pb	No leachate generated	

[a] Land DMEG was used when bulk solid samples were analyzed.

[b] Water DMEG was used when distilled-water leachate was analyzed.

[c] Coal and sorbent fuel streams were not compared to land DMEGs. The only environmental effect possibly associated with these streams is leaching (due to rainwater runoff, for example). Therefore, only the leachates were evaluated.

[d] Not only was no element observed to exceed its health or ecological DMEG, but the vast majority were more than two orders of magnitude below their DMEG.

TABLE 38. ANALYSIS OF LABORATORY-GENERATED LEACHATES FOR ANIONS

Anion	Detection limit	Sample analyzed (concentrations in μg/l)					
		EX 1-1-05-FAR Regen. cyclone catch	EX 1-1-06-CB-Spent combustor bed material	EX 1-1-07-FA2-second cyclone catch	EX 1-1-08-FAB-Third cyclone catch	EX 1-1-09-CF-coal feed	EX 1-1-10-SF-Sorbent feed
F^-	50	9300	4000	6200	5000	ND	ND
Cl^-	100	33300	12200	17000	38700	2000	1500
Br^-	100	ND	ND	ND	ND	ND	ND
NO_2^-	80	ND	ND	ND	ND	ND	ND
NO_3^-	100	ND	ND	ND	ND	ND	800
$SO_4^=$	100	2.4×10^6	7.5×10^5	1.5×10^6	2.3×10^6	8.5×10^5	7000
$PO_4^{\equiv}$	100	ND	ND	ND	ND	ND	ND

Note: ND = Not detectable.

TABLE 39. COMPARISON BETWEEN CONCENTRATIONS OF ANIONS IN FBC LEACHATE AND MAXIMUM PERMISSIBLE CONCENTRATIONS IN DRINKING WATER

Anion	Maximum permissible concentration (mg/l)[a]	Sample					
		Regen. cyclone	Comb. spent bed	Second cyclone	Third cyclone	Coal feed	Sorbent feed
F^-	1.4 - 2.4	9.3	4.0	6.2	5.0	ND[b]	ND
NO_3^- (as N)	10	ND	ND	ND	ND	ND	800
Cl^-	250	33.3	12.2	17.0	38.7	2.0	1.5
$SO_4^=$	250	2400	750	1500	2300	850	7.0

[a] Fluoride and nitrate limits are set under EPA National Interim Primary Drinking Water Regulations (40 CFR 141); chloride and sulfate under EPA National Secondary Drinking Water Regulations (40 CFR 143).

[b] Not detectable. Detection limits were 500 μg/l.

Data indicate that all four Exxon solid waste streams exceed primary drinking water limits for fluoride. All solid streams except sorbent feed exceed secondary drinking water limits for sulfate.

Typically, a safety factor of 100 is used when comparing concentrations of chemicals in industrial effluent with drinking water standards to allow for dilution effects. That is, any concentration 100 times or less the drinking water regulation is not considered a problem. Using this safety factor, FBC solids' laboratory-generated leachate should pose minimal concern.

Coal Analyses--

In addition to the chemical analyses described above, the coal feed stream was submitted for proximate and ultimate analysis. Results are listed in Table 40.

Liquid Waste Stream Analysis

A single sample of the scrubber slurry water was provided by Exxon for field analysis by GCA. Field analysis was by Hach Kit. The results of analysis on a one liter aliquot are presented in Table 41.

ORGANIC ANALYTIC RESULTS

Samples from the Exxon Miniplant generally contained low levels of organic compounds compared to DMEG[14] and Level 1 organic analysis criteria.[1]

The SASS-train organic module (XAD-2, resin adsorbent extracted with CH_2Cl_2 from the regenerator flue gas stream and the diluted combustor flue gas stream were the only samples analyzed that contained sufficient organic

TABLE 40. COAL ANALYSIS

Proximate		Ultimate	
Moisture	2.72%	C	81.41%
Volatile	37.61	H	6.02
Fixed	52.62	N	1.51
Ash	7.05	O	2.09
S	1.6%	CI	not done
Btu	13,522 Btu/lb		
Free swelling index	7½		

TABLE 41. SCRUBBER SLURRY ANALYSES

pH	7
Acidity	methyl orange = 0 phenolphthalein = 1200 mg/l
Alkalinity	130 mg/l
Chlorine residual	0
Hardness	100 mg/l
Conductivity	8500 μm mhos/cm specific conductance
Ammonia	1.2 mg/l
Sulfide	≤ 0.1 mg/l

material to require liquid chromatographic separation. Because organic concentrations were so low the infrared spectrophotometry and low resolution mass spectrometry analyses provided only general results that were of limited use. The complete organic data are presented in Appendix A. The most relevant results of organic analysis are summarized and discussed below. These results center on the gaseous stream sampleswhich required LC separation. Organic content of solid samples was so low that discussion of results would suffer from over interpretation of the limited data generated. Organic data for solid samples are in Appendix A.

Gaseous Waste Streams

Table 42 lists and summarizes the organic analytic results for gaseous waste stream components sampled and analyzed at the Exxon Miniplant. Included are results for the Dilution Compressed Air stream and particulates collected by the ESP as well. Results are expressed not only as the concentration of CH_2Cl_2-extractable organics per volume gas sampled (mg/m^3) but also as an emission rate in milligrams/second. The results of TCO and GRAV analyses show that only streams 1 and 3 (diluted combustor flue gas and regenerator flue gas) exceed the 15 mg total TCO + GRAV trigger which mandates additional liquid chromatographic (LC) separation and subsequent analysis of LC fractions (see Reference 1 pp. 140-148).

The objective of the LC procedure is to separate the sample into fractions of various discrete chemical classes to aid in further analysis which might eventually provide information leading to identification of organic species present. However, the LC procedure used in Level 1 is not a high resolution technique; the seven LC fractions obtained by following the Level 1 procedure represent only a gross separation and there is broad overlap in class type between many of the fractions.

The results of the LC fractionation procedure include quantitative estimates of TCO and GRAV range organic materials in each of the seven fractions. These values have been converted to equivalent concentrations at the source (in $\mu g/m^3$) for the two flue gas streams analyzed. This data conversion facilitates comparison of LC results with DMEG decision criteria. Data obtained from onsite gas chromatography (GC) for low boiling point organics were also converted in this manner for comparison with DMEGs.

A survey was made of those organic compounds potentially present in both LC and GC fractions for which DMEG values have been adopted. These compounds were categorized as potentially present in the GC (gaseous), TCO (volatile), or GRAV (nonvolatile) boiling point ranges. This review resulted in a list of candidate compounds for both GC and LC fractions whose specific DMEG limits could be compared with GC and LC TCO or GRAV data. By assuming that the total emissions of organic species within a fraction consisted solely of that candidate compound with the lowest DMEG, organic compounds of potential concern could be determined. The accuracy or plausibility of such identifications must be contrasted with the previously recognized limitations of the Level 1 LC fractionation scheme.

TABLE 42. SUMMARY OF ORGANIC ANALYTIC RESULTS OF EXXON MINIPLANT GASEOUS STREAMS

Samples analyzed	TCO			GRAV			Total		
	mg	mg/m^3	mg/s[a]	mg	mg/m^3	mg/s	mg	mg/m^3	mg/s
Stream 1 - Diluted combustor flue gas[b]									
Fine particles	NA[c]	NA	NA	--[d]	--	--	--	--	--
Coarse particles	NA	NA	NA	7.3	0.23	0.08	7.30	0.23	0.08
XAD module	3.7	0.12	0.05	65.0	2.1	0.80	69.0[e]	2.22	0.85
ESP hopper catch[f]	0.66	0.01	0.007	4.9	0.77	0.047	5.56	0.08	0.05
Stream 2 - Undiluted combustor flue gas[g]									
XAD module	2.0	0.01	0.002	11.0	0.72	0.17	13.0	0.73	0.17
Stream 3 - Regenerator flue gas[g]									
Fine particles	NA	NA	NA	NA	NA	NA	NA	NA	NA
Coarse particles	NA	NA	NA	NA	NA	NA	NA	NA	NA
XAD module	200	6.0	0.27	370	11.0	0.50	570[e]	17.0	0.77
Stream 4 - Dilution air[g]									
XAD module	1.5	0.30	0.04	1.8	0.35	0.05	3.3	0.65	0.10

[a] Calculated using flow rates summarized in Table 4.

[b] Sample analyzed was collected on day 3.

[c] NA = not analyzed.

[d] -- = no results, blank correction problems.

[e] Exceeds the 15 mg TCO + GRAV Level 1 trigger; liquid chromatographic (LC) separation and low resolution mass spectrometry (LRMS) required.

[f] Data are based on particulate loading of 112 mg/m^3, as measured and reported by Acurex.

[g] Sample analyzed was collected on day 2.

Table 43 lists those organic species determined to have the lowest DMEG within a given GC or LC (TCO or GRAV) fraction. Tables 44 and 45 summarize comparisons made between GC data and LC fraction TCO and GRAV data for both flue gas streams (the only samples that met the criteria for LC separation) with the lowest DMEG pertinent to that fraction; organic compounds of potential concern are determined by taking the ratio of the emission rate for a specific fraction and the lowest DMEG for candidate organic compounds within that fraction (i.e., a Maximum Discharge Severity is calculated). A value $\geq$ 1.0 indicates that some organic compounds within that fraction may exceed their respective emission goals. The number of such compounds is listed for each fraction along with a tentative identififation.

BIOASSAY TEST RESULTS

Level 1 bioassay results of Exxon Miniplant samples are summarized in Table 46.

Health Effects

Ames Test Results--

Results of testing Exxon Miniplant samples in the Ames Salmonella/microsome mutagenicity test are summarized in Table 47.

Five samples were positive (mutagenic) in the Ames test. With the exception of the third cyclone catch, all streams exhibited low toxicity to RAM cells. Regenerator flue gas XAD-extract was the only sample toxic to CHO cells. Regenerator cyclone catch leachate, spent combustion bed material leachate, and second cyclone catch leachate all exhibited high toxicity in all ecological effects tests. Third cyclone catch leachate was variably toxic in these tests depending on the organism exposed.

Positive Ames response was based on a threefold criterion. Samples tested had to demonstrate dose-responsiveness over three consecutive dose ranges, a number of revertants — a minimum of twice that of the historical background of the tester strain, and reproducibility of the observed response. No toxicity was observed with any solid sample tested at 5000 μg. Sample availability was not sufficient to test for toxicity at higher doses. Some toxicity was evident when the two XAD-extract samples were tested. Subsequent testing was run over the nontoxic concentration range.

An estimation of the mutagenic potency of these samples may be made by the data presented in Table 48.

It must be emphasized that the positive mutagenic response observed for these several FBC effluent streams is not a result unique to FBC processes nor to coal combustion effluent streams in general. Based on a survey of the literature it appears evident that production of atmospheric mutagens is not a phenomenon limited to certain specific sources. Several reports have been published regarding the mutagenicity of ambient air collected near various sites both in the U.S. and elsewhere.[17-22]

TABLE 43. ORGANIC COMPOUNDS WITH THE LOWEST AIR DMEG WITHIN DESIGNATED LEVEL 1 FRACTIONS

Level 1 fractions	Organic compounds or classes[a]	Air Discharge Multimedia Environmental Goals (μg/m³) Health-based	Air Discharge Multimedia Environmental Goals (μg/m³) Ecology-based	Comments
Gaseous (GC)				
GC1	Acetylene	2.7×10^{6} [b]	--[c]	
	Methane	3.3×10^{6}	6.5×10^{6}	
	Ethylene	5.7×10^{6}	1.0	
GC2	Bromobutanes	5.6×10^{4}	--	
	Propyne	1.7×10^{6}		
	Propylene	8.6×10^{6}	1.8×10^{5}	
GC3	Diazomethane	400	--	Diazomethane is unstable; it is decomposed by heat, shock, and oxidizing agents. Therefore, the likelihood that it would be present in FBC emission streams is negligible. The value for formaldehyde is used.
	Formaldelyde	1200	--	
	Vinyl chloride	2600	--	
GC4	Methyl bromide	6×10^{4}	--	
GC5	Acrolein	250	--	
	Ethyleneimine	330	--	
	Methyl Iodide	850	--	
GC6	N,N´-Dimethylhydrazine	32	--	N,N´-Dimethylhydrazine is unstable. This substance is a rocket fuel and its relevance to combustion processes is negligible. The value for benzene is used.
	Benzene	3000	--	
	Carbon tetrachloride	1.3×10^{4}	--	
GC7	No Information	X	X	
Volatile (TCO)				
LC1	Heptanes, octanes	3.5×10^{4}	--	
LC2	Hexachlorocyclopentadiene	110	--	
	Isopropylbenzene		1200	
LC3	PCBs	1	--	
LC4	1,1´-Dichlorometylether	5	--	
LC5	N-Nitrosodiethylamine	65	--	
LC6	1,4-Diaminobenzene	100	--	
LC7	Dimethyl Sulfoxide	810	--	
Nonvolatile (GRAV)				
LC1	No Information	X	X	
LC2	Hexachlorocyclohexane	500	--	
LC3	Benzo(a)pyrene	0.02	--	
LC4	2-Chloroethyl ethyl ether	1.1×10^{4}		
LC5	3,4-Dinitrotoluene	1500	--	
LC6	Dibenzo(r,g)carbazole	100	--	
LC7	2,4,6-Trinitrophenol	100	--	
	3,3'-Dichlorobenzidine	100	--	

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[a] Compounds or classes in designated GC fractions or LC fractions are based on data in EPA-600/7-79-033, EPA/IERL-RTP Procedures for Level 2 Sampling and Analysis of Organic Materials.

[b] ⬭ Lowest discharge goal for the respective fraction is circled.

[c] -- No goals have been set.

TABLE 44. COMBUSTOR FLUE GAS ORGANIC ANALYTIC RESULTS

Level 1 sample fraction designation	Emissions ($\mu g/m^3$)	Maximum discharge severity[a]	Candidate organic compounds of concern	
			Number	Examples
Gaseous				
GC1	3000	0.001(3000, ecological)	1	Ethylene(ecologically-based)
GC2	< 150	<0.003	0	
GC3	< 200	<0.2[b]	0	
GC4	1500	0.025	0	
GC5	< 300	<1.2	1	Acrolein
GC6	< 400	<0.1[c]	0	
GC7	< 450	No information available	0	
Volatile (TCO)[d]				
LC1	49	0.001	0	
LC2	2.8	0.025(0.002, ecological)	0	
LC3	14	14	1	PCBs
LC4	13	2.6	1	1,1´-Dichloromethylether
LC5	2.5	0.04	0	
LC6	6.6	0.07	0	
LC7	5.6	0.05	0	
Nonvolatile (GRAV)[d]				
LC1	3300	No information available	0	
LC2	70	0.14	0	
LC3	12	600	6	Benzo(a)pyrene, other PNAs
LC4	34	0.003	0	
LC5	28	0.02	0	
LC6	< 1	<0.01	0	
LC7	450	4.5	4	2,4,6-Trinitrophenol, 3,3´-Dichlorobenzidine, Denitro-p-cresols, 4,4´-Methylene bis (2-Chloroaniline)
Particulate[d]				
Coarse	230	Insufficient information to assign probable compound types		
Fine	No information available, blank correction problem			

[a] Max. DS based on air, health DMEG except where noted, using those organic species listed for each fraction in Table 30.

[b] Maximum DS would be 0.5 if diazomethane were considered. See comment in Table 30.

[c] Maximum DS would be 13 if N,N´-dimethylhydrazine were considered. See comment in Table 30.

[d] Results represent measurements in the diluted flue gas stream multiplied by a conversion factor of 1.64 to correct to the undiluted flue gas volume. This correction ignores the potentially significant contribution from the compressed dilution air. This is a worst-case assumption for calculating emissions in the undiluted combustor flue gas

TABLE 45. REGENERATOR FLUE GAS ORGANIC ANALYTIC RESULTS

Level 1 sample fraction designation	Emissions ($\mu g/m^3$)	Maximum discharge severity[d]	Candidate organic compounds of concern	
			Number	Examples
Gaseous				
GC1	6×10^5	0.2(6×10^5, ecological)	1	Ethylene(ecologically-based)
GC2	< 150	< 0.003	0	
GC3	< 200	< 0.2[a]	0	
GC4	2500	0.04	0	
GC5	< 300	< 1.2	1	Acrolein
GC6	< 400	< 0.1[b]	0	
GC7	< 450	No information available	0	
Volatile (TCO)				
LC1	260	0.0007	0	
LC2	15	0.14(0.013, ecological)	0	
LC3	230	230	1	PCBs
LC4	2.8	0.56	0	
LC5	5.3	0.08	0	
LC6	8.0	0.08	0	
LC7	3.9	0.005	0	
Non-volatile (GRAV)				
LC1	4000	No information available	0	
LC2	1400	3	1	Hexachlorocyclohexane(Lindane)
LC3	3500	1.75×10^5	29	Benzo(a)pyrene, dibenz(a,h) anthracene and other PNAs
LC4	130	0.01	0	
LC5	84	0.06	0	
LC6	73	0.7	0	
LC7	63	0.6	0	
Particulate[c]	--	--	--	

[a] Max. DS would be 0.5 if diazomethane were considered. See comments in Table 30.

[b] Max. DS would be 13 if N,N′-dimethylhydrazine were considered. See comments in Table 30.

[c] Not analyzed, no data. Sample quantities were below Level 1 analytic criteria

[d] Maximum discharge severity is based on air, health DMEG, unless noted otherwise, using those organic species listed for each fraction in Table 30.

TABLE 46. SUMMARY OF BIOASSAY RESULTS OF EXXON PFBC SAMPLES

	Health Effects Tests			Ecological Effects Tests		
Sample Description	Ames mutagenicity[a]	RAM cytotoxicity[b]	CHO cytotoxicity	Fish (96-hour LC_{50})	Daphnids (48-hour LC_{50})	Algae (EC_{50})
Scrubber slurry	--	N[c]	--	High (4.0%)	High (4.0%)	Moderate (23.3%)
XAD blank	--	N	--	N	N	N
Combustor flue gas - XAD	+ (2 μℓ)[d]	N	--	N	N	N
Regenerator flue gas - XAD	+ (0.4 μℓ)	N	High (+[e])	N	N	N
Fine SASS particulate	+ (5 mg)	N	N	N	N	N
Coarse SASS particulate	+ (1 mg)	N	N	N	N	N
SASS filter-control	--	N	N	N	N	N
ESP hopper ash	+ (1 mg)	Low (0.64 mg/mℓ)	N	N	N	N
Regenerator cyclone	--	Low (0.67 mg/mℓ)	N	High (11.8%)	High (15.0%)	High (4.6%)
Combustor bed material	--	Low (0.51 mg/mℓ)	N	High (11.6%)	High (7.5%)	High (4.5%)
2^{o} cyclone catch	--	Low (0.45 mg/mℓ)	N	High (12.5%)	High (5.5%)	High (6.3%)
3^{o} cyclone catch	--	Moderate (0.04 mg/mℓ)	N	Low (93.8%)	Moderate (43.6%)	High (19.3%)

[a] ± = Positive or negative mutagenic response; no detectable toxicity

[b] Values in parentheses are EC_{50} for cell viability

[c] N indicates this assay not run for the indicated sample

[d] Values in parentheses for Ames test indicate lowest recorded concentration resulting in positive response.

[e] + = Greater than 50 percent reduction in plating effeciency

TABLE 47. SUMMARY OF AMES MUTAGENICITY TEST DATA

Sample tested	Result	Tester strains	LRPC[a]
Fine combustor flue gas particles (SASS catch <3μm)	+	TA1538, TA98	5000 μg/plate
Coarse combustor flue gas particles (SASS catch >3μm)	+	TA1537, TA1538, TA98	1000 μg/plate
Combustor flue gas XAD	+	TA1537, TA1538, TA98	2 μℓ/plate
ESP hopper catch	+	TA1537, TA1538, TA98	1000 μg/plate
Regenerator flue gas XAD	+	TA1537, TA1538, TA98	0.4 μℓ/plate
Regenerator cyclone catch	-		
Spent combustor bed material	-		
Second cyclone catch	-		
Third cyclone catch	-		
XAD blank	-		
Particulate filter control	-		

[a] LRPC = Lowest recorded positive concentration.

TABLE 48. POTENCY OF AMES-POSITIVE EXXON PFBC SAMPLES

Sample	LRPC[a]	Organics[c] at LRPC	Revertants[b]/μg Organics[c] at LRPC
Fine (<3 μm) combustor flue gas particles	5000 μg	No data	-
Course (>3 μm) combustor flue gas particles	1000 μg	25 μg	1.2
Combustor flue gas-XAD extract	2 μℓ	4.4 μg	5.5
ESP hopper catch	1000 μg	0.7 μg	110
Regenerator flue gas-XAD extract	0.4 μℓ	15 μg	8.6

[a] LRPC = Lowest recorded positive concentration.

[b] Most responsive strain was used. Revertants were after subraction of background.

[c] Methylene chloride extractable materials.

Mutagenicity of combustion emissions and energy conversion systems has been demonstrated by several investigators. Chrisp et al. have presented data on mutagenicity of coal fly ash collected downstream of the electrostatic precipitator of a modern power plant burning pulverized, low sulfur, high ash coal.[23] Löfroth has demonstrate mutagenic activity in emissions from a hot-water boiler burning peat or wood chips.[24] Epler et al. have investigated the positive mutagenic response of crude products and effluents from oil-shale, coal-liquefaction, and coal-gasification processes.[25]

The data presented here corroborate the work of other investigators testing FBC effluents. The mutagenic response of these Exxon samples (where they are able to be compared) is similar to that observed previously at Exxon[26] and by those responses of samples obtained from Morgantown Energy Technical Center.[27]

Cytotoxicity Tests

CHO test--

CHO cytotoxicity test data shcw that the XAD extract of the regenerator flue gas exhibited a high toxicity for CHO cells when dose/response is compared to the criteria listed in Table 30. Two microliters per plate of this extract was sufficient to cause an 88 percent reduction in cell plating efficiency. All other samples tested using CHO were nontoxic.

RAM test--

RAM test data are summarized in Table 49.

TABLE 49. EC_{50} VALUES BASED ON CELL VIABILITY IN THE RAM CYTOTOXICITY TEST

Sample tested	EC_{50} (μg/mℓ)	Relative toxicity[a]
Regenerator cyclone catch	670	Low
ESP hopper catch	640	Low
Spent combustion bed	510	Low
Second cyclone catch	450	Low
Third cyclone catch	40	Moderate

[a] Using response criteria listed in Table 42.

EC_{50} values were calculated based on cell viability. In general, EC_{50} values calculated based on ATP concentrations were similar to those based on viability.

Ecological Effects Tests

Results of all ecological effects tests are summarized in Table 50.

TABLE 50. SUMMARY OF ECOLOGICAL EFFECTS TESTS. LC_{50} AND EC_{50} VALUES OF EXXON EFFLUENTS EXPRESSED AS PERCENT CONCENTRATION (AT 95 PERCENT CONFIDENCE LEVEL)[a]

Sample	Time of observation (hours)	Fathead minnow LC_{50}	*Daphnia magna* LC_{50}	Algol[b] EC_{50}
Regenerator cyclone catch	24	11.8 (6.7, 17.0)	15.0 [5.0, 25.0]	--
	48	11.8 (6.7, 17.0)	15.0 [5.0, 25.0]	--
	96	11.8 (6.7, 17.0)	--	4.6
Spent combustion bed material	24	12.0 (6.5, 17.5)	9.4 (8.1, 10.7)	--
	48	12.0 (6.5, 17.5)	7.5 (6.1, 8.9)	--
	96	11.6 (8.5, 14.7)	--	4.5
Second cyclone catch	24	12.5 [10.0, 15.0]	12.5 [10.0, 15.0]	--
	48	12.5 [10.0, 15.0]	5.5 (4.1, 6.9)	--
	96	12.5 [10.0, 15.0]	--	6.3
Third cyclone catch	24	None (16/20 survived in 100 percent effluent)	None (11/20 survived in 100 percent effluent)	--
	48	None (12/20 survived in 100 percent effluent)	43.6 (36.9, 51.5)	--
	96	93.8 [75.0, 100.0]	--	19.3

[a] In cases where an LC_{50} could not be derived from probit analyses, it was linearly interpolated and the confidence interval is substituted by the two surrounding test concentrations given in brackets.

[b] EC_{50} calculated from growth rate days 0-4.

[c] Laboratory-generated distilled water leachates of the bulk solid samples listed were tested in these assay systems.

Fish Tests--

Test data from the 96-hour, static, acute freshwater bioassays with fathead minnow indicate that leachates of spent combustion bed material, regenerator cyclone catch, and second cyclone catch were highly toxic (50 percent mortality of fish at less than 20 percent (v/v) leachate concentration) to fathead minnow. The third cyclone leachate exhibited low toxicity.

Daphnid Tests--

Results of this assay were similar to those for fathead minnow. The second cyclone, spent combustion bed, and regenerator cyclone leachates were highly toxic to daphnids. The third cyclone sample was moderately toxic.

Algae Tests--

All four leachate samples were highly toxic to algae. Review of the test data reveals that the toxicities observed in all the ecological tests were a function of test pH. Invariably, when mortality was observed, the pH of the system was above the desirable range for the test organisms used (6.5-8.0). That pH was the causative factor in organism death was corroborated by data from trace elemental analysis of the leachates tested. Potentially toxic elemental species were present at such low concentrations in these leachates that they could not have been responsible for the observed effects. Although alkaline pH of laboratory-generated leachates is a valid endpoint to be noted, the effect of these samples on the aquatic organisms tested cannot be considered significant. At present, Level 1 testing does not provide for neutralization of leachates prior to testing so as to factor out pH as a causative agent. Until pH effects can be isolated in this manner, the high toxicity observed from Exxon samples in these tests must be considered equivocal responses, and these leachate samples must be relegated to a lower priority for future testing compared to other (e.g., flue gas particulate) emission streams.

SECTION 6

LEVEL 2 CHEMICAL INVESTIGATION OF EXXON MINIPLANT SAMPLES

Limited Level 2 chemical analysis was performed on selected Exxon stream samples. Samples selected for Level 2 analysis were those suspected of containing polynuclear aromatic (PNA) species based on LRMS data (see Appendix A) or those samples which had demonstrated positive mutagenic response in the Ames test. Even though Ames test results indicated that PNA species could not be solely responsible for the observed mutagenic response because of the lack of activity in the presence of S-9 mix, quantification of PNA species in Exxon samples still provides valuable compound-specific information which will aid in selection of appropriate fractionation schemes for future analysis.

Our initial Level 2 analysis involved screening of selected Exxon samples using high performance liquid chromatography (HPLC) with fluorescence detection. Analytical procedures and instrumental operating conditions have been described in Section 4.

Table 51 lists those samples analyzed by HPLC/fluorescence. Where duplicate samples were available, both were analyzed. XAD-2 resin samples had been previously CH_2Cl_2-extracted for Level 1 analysis.

Table 52 presents a summary of results and compares levels of PNAs detected with their respective emission goals (DMEGs). Data indicate that XAD extract from both flue gas streams analyzed contain levels of 1,2,5,6-dibenzanthracene in excess of air DMEG levels and thus warrant further investigation. Although SASS particle samples might contain PNA species in quantities sufficient to require more detailed investigation, sample size available prohibits any further analysis. In addition, further analysis would only be justified on a worst-case basis, that is, if the more hazardous compound among those which coelute represented most or all of the quantity listed. That this is the case is extremely unlikely.

TABLE 51. EXXON SAMPLES SCREENED BY HPLC/FLUORESCENCE

Level 1 stream designation	Stream description[a]
EX 1-3-01-CC	SASS coarse particles (>3 μm) entrained in diluted combustor flue gas
EX 1-3-01-FC	SASS fine particles (<3 μm) entrained in diluted combustor flue gas
EX 1-3-01-FA	ESP hopper ash
EX 1-1-02-XM	XAD-2 extract, undiluted combustor flue gas, day 1
EX 1-2-02-XM	XAD-2 extract, undiluted combustor flue gas, day 2
EX 1-1-03-XM	XAD-2 extract, regenerator flue gas, day 1
EX 1-2-03-XM	XAD-2 extract, regenerator flue gas, day 2
EX 1-2-02-XMB	XAD-2 blank
EX 1-2-03-XMB	XAD-2 blank

[a] Resin samples had been previously extracted with CH_2Cl_2 for level 1 analysis. Particulate and ESP samples were CH_2Cl_2-extracted for this procedure.

TABLE 52. RESULTS OF HPLC/FLUORESCENCE SCREENING OF EXXON MINIPLANT SAMPLES FOR POLYNUCLEAR AROMATIC HYDROCARBONS

PNA	Emission goal[a]		Coarse (>3 μm) SASS particles - combustor flue gas	Fine (<3 μm) SASS particles - combustor flue gas	ESP hopper ash	XAD extract - combustor flue gas - day 1	XAD extract - combustor flue gas - day 2	XAD extract - regenerator flue gas - day 1	XAD extract - regenerator flue gas - day 2
	Air (μg/m³)	Land (μg/g)							
Naphthalene	50000	150000	<650	<65	<18	<10	<68	840	6300
Anthracene	56000	170000	<11	<1.1	<0.31	<0.17	0.27	4.1	33
Fluoranthene/Pyrene[b]	90000	28000	75	8.5	5.2	50	<0.71	55	120
2-Methyl anthracene	-	-	<75	<7.5	<2.1	<0.11	<0.75	<5.5	<48
Benz(a)anthracene/Triphenylene/Chrysene[b]	45	134	<0.8	<0.08	0.019	1.0	0.006	2.0	16
Benzo(k)fluoranthene	1600	4500	<0.08	<0.008	<0.002	0.056	<0.001	0.16	1.7
Benzo(a)pyrene/Benzo(e)pyrene[b]	0.02	0.06	<0.28	0.18	<0.008	<0.004	0.013	0.82	11
7,12-Dimethylbenzanthracene/1,2,3,4-Dibenzanthracene[b]	0.26	0.78	<20	<2	<0.56	<0.29	<0.20	14	100
1,2,5,6-Dibenzanthracene	0.093	0.28	<0.55	<0.055	<0.015	0.25	<0.006	0.25	1.0
Indeno(1,2,3,cd)pyrene	1630	4800	<25	3.2	1.9	6.2	<0.25	50	74
Benzo(g,h,i)perylene	-	-	<0.94	<0.091	<0.025	<0.001	<0.009	0.61	9.8
Ananthracene	-	-	<30	<3.0	9.4	<0.50	<0.30	<23	<19
Coronene	-	-	<0.15	<0.015	<0.004	<0.002	<0.002	0.055	1.1

[a] Health-based Discharge Multimedia Environmental Goals are used. Air DMEGs in μg/m³ should be used for comparison of results for gaseous streams and land DMEGs in μg/g for solid streams. - indicates that no goals have been adopted for these species.

[b] These species coelute under our experimental conditions. In these instances, the most stringent DMEG is indicated.

Note: Circled values indicate those species which exceed their respective emission goals and indicate areas of potential concern. Values reported as "less than" or values for which there is potential coelution of several PNAs were deemed inconclusive data and are circled with dashed lines.

SECTION 7

RADIOASSAY OF EXXON MINIPLANT SAMPLES

Multimedia samples collected during the May 1979 Level 1 sampling program at the Exxon Miniplant were analyzed for selected radioisotopes. Radioisotope emissions data from fluidized-bed combustion are required by the EPA-Office at Radiation Programs to evaluate the need, if any, for emissions limitations or other standards or criteria as instructed by the Clean Air Act Amendments. Also, these data serve as an initial effort toward incorporation of radioactivity (as an environmental pollutant) into the environmental assessment methodology developed by the EPA-Office of Research and Development through IERL-RTP.

Table 53 summarizes the radioanalyses performed on available Exxon Miniplant samples. Stream numbers are those sampling points indicated in Figure 2 and described in Table 6. In all, seven solid samples were analyzed. Coal and sorbent feedstocks were only analyzed for isotopic uranium and isotopic thorium. The remaining samples were analyzed for isotopic uranium, isotopic thorium, radium-226, actinium-228, lead-210, and polonium-210.

RESULTS AND DISCUSSION

Results of radioanalysis of Exxon Miniplant Level 1 samples are summarized in Table 54. ESP hopper ash was not available in sufficient quantity to permit analysis for thorium isotopes. The data show higher radioisotope concentrations in the relatively fine particles collected by the final control device (stream 1). Cascade impactor measurements showed that the particles entering the final control device are 95 percent less than 4 µm by mass and 50 percent less than 2 µm.[28] Secondary cyclone catch typically has a volume median diameter (determined by Coulter Counter) of 17 µm, and the third cyclone catch typically has a median diameter of 4-6 µm.[29]

Data listed in Table 55 illustrate the flow of individual isotopes through the systems sampled. In Level 1, spent combustion bed material is all regenerated or elutriated and collected by the cyclones so the flow rate is zero. Total amount of isotope into the system is equal to that in the coal plus the sorbent. For isotopes not quantified in the feed streams, secular equilibrium is assumed to exist and activity is assumed equal to that for the parent isotopes (^{238}U or ^{232}Th) that have been measured. Stream flow rates for final particle control devices are assumed equal to the flow rate for undiluted flue gas multiplied by the average dust loading measured for that stream (i.e., the final control device operates at high collection efficiencies).

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TABLE 53. RADIOANALYSIS OF EXXON MINIPLANT SAMPLES

Stream number and description	Isotopes (half-life)								
	^{235}U	^{238}U	^{228}Th	^{230}Th	^{232}Th	^{226}Ra	^{210}Pb	^{210}Po	^{228}Ac
	$7.1x10^{8}y$	$4.5x10^{9}y$	1.9y	$8.0x10^{4}y$	$1.4x10^{10}y$	$1.6x10^{3}y$	19.4y	138d	6.1h
Exxon Level 1 samples									
1 ESP hopper ash	A	A	B[a]	B[a]	B[a]	C	D	E	F
5 Solids collected by reg. cyclone	A	A	B	B	B	C	D	E	F
6 Spent bed solids	A	A	B	B	B	C	D	E	F
7 Solids collected by second cyclone	A	A	B	B	B	C	D	E	F
8 Solids collected by third cyclone	A	A	B	B	B	C	D	E	F
9 Coal feed	A	A	B	B	B	G	G	G	G
10 Sorbent feed	A	A	B	B	B	G	G	G	G

Analytical techniques

Notes:

A Isotopic uranium (all U isotopes) by α spectrometry.
B Isotopic thorium (^{228}Th, ^{230}Th, ^{232}Th) by α spectrometry.
C Lucas emanation technique - incorporates α counting.
D β-counting of ^{210}Bi daughter following solvent extraction.
E α-counting of electroplated disk.
F Radiochemical analysis of ^{228}Ra - β-counting of ^{228}Ac ingrowth after 36h.
H Can be calculated assuming secular equilibrium.

[a] ESP hopper ash sample was not available in sufficient quantity to permit analysis for thorium isotopes.

TABLE 54. RESULTS OF RADIOANALYSIS OF EXXON MINIPLANT SAMPLES

Sample number and description	Activity in pCi/g(dry)±SD at 2 sigma confidence									
	^{238}U	^{234}U	^{235}U	^{228}Th	^{230}Th	^{232}Th	^{226}Ra	^{228}Ac	^{210}Pb	^{210}Po
Level 1 samples										
1 ESP hopper ash	4.7±0.8	4.8±0.8	<0.3	I[a]	I	I	5.2±1.3	3.6±0.5	1.4±0.3	10±0.8
5 Solids collected by regenerator cyclone	1.2±0.3	1.3±0.3	<0.4	<0.34	<0.34	<0.34	1.2±0.2	0.7±0.2	<6.0	<0.02
6 Combustion bed material	0.38±0.34	<0.2	<0.4	0.47±0.36	0.47±0.36	0.34±0.29	0.59±0.02	0.26±0.07	<8.0	0.041±0.014
7 Solids collected by second cyclone	<0.9	1.3±0.8	<2.0	0.23±0.21	<0.19	0.27±0.24	1.8±0.3	1.3±0.1	<10.0	0.15±0.02
8 Solids collected by third cyclone	1.1±1.0	2.0±0.8	0.96±0.87	1.2±0.5	1.4±0.6	1.3±0.5	4.3±1.0	2.8±0.5	<8.0	0.082±0.019
9 Coal feed	<0.3	0.12±0.11	<0.4	0.16±0.15	0.44±0.32	0.25±0.22	<0.3[b]	0.25±0.22[b]	<0.3[b]	<0.3[b]
10 Sorbent feed	<0.3	0.25±0.15	<0.2	<0.14	<0.42	<0.14	<0.3[b]	<0.14[b]	<0.3[b]	<0.3[b]

[a] I = Indicates that there was insufficient sample available to run the analysis

[b] Isotope levels were estimated by assuming secular equilibrium exists

TABLE 55. FATE OF INDIVIDUAL ISOTOPES WITHIN THE EXXON MINIPLANT PFBC DURING LEVEL 1 TESTING

Sample number and description	Radioisotope flow rate, pCi/s										
	Solid flow rate (g/s)	^{238}U	^{234}U	^{235}U	^{228}Th	^{230}Th	^{232}Th	^{226}Ra	^{228}Ac	^{210}Pb	^{210}Po
9 Coal feed	21.4[b]	<6.4	2.6	<8.6	3.4	9.4	5.4	<6.4	5.4	<6.4	<6.4
10 Sorbent feed[a]	1.5[b]	<0.5	0.4	<0.3	<0.2	<0.6	<0.2	<0.5	<0.2	<0.5	<0.5
Total activity in	--	<6.9[d]	3.0	<8.9	3.4-3.6	9.4-10.0	5.4-5.6	<6.9[g]	5.4-5.6[g]	<6.9[g]	<6.9[g]
3 Cleaned regenerator off gas	0.0002[c]	0[e]	0[e]	0[e]	0[e]	0[e]	0[e]	0[e]	0[e]	0[e]	0[e]
5 Regenerator cyclone solids	0.2[b]	0.3	0.3	<0.1	<0.1	<0.1	<0.1	0.3	0.2	<1.6	<0.01
6 Spent combustion bed solids	0	0	0	0	0	0	0	0	0	0	0
7 Second cyclone solids	1.6[b]	<1.5	2.2	<3.3	0.4	<0.3	0.5	3.0	2.2	<16.7	0.3
8 Third cyclone solids	0.4[b]	0.5	0.9	0.4	0.5	0.6	0.6	1.9	1.2	<3.5	0.04
1 ESP hopper ash	0.042[c]	0.2	0.2	<0.01	NA[f]	NA	NA	0.2	0.15	0.06	0.4
Total activity out	--	1.0-2.5	3.6	0.4-3.7	0.9-1.0	0.6-1.0	1.1-1.2	5.5	3.8	<22	0.74

[a] Sorbent feed rate was calculated from the Ca/S molar ratio of 1.29, 1.67% S coal and sorbent = 95% $CaCO_3$.

[b] Measured by Exxon Research and Engineering during test program.

[c] Based on particulate concentrations measured by Exxon Research and Engineering and gas flow rates determined by GCA.

[d] Totals were obtained by adding the contributions of coal and sorbent. Where one of these values is indicated, a "less than" a range of possible values is given. Where other values are "less than," a maximum value is indicated.

[e] Not measured but believed to be near zero relative to the other streams because of the low solid flow rate.

[f] NA = data are not available. There was insufficient sample size. Contributions to the total activity from the samples should be minimal.

[g] These values assume secular equilibrium exists.

Because the Miniplant is a small experimental unit, its relationship to a full-scale commercial plant needs to be considered. A commercial plant would consist of several modules with a total thermal input capacity near 1500 MW (5120 x 10^6 Btu/hr). Sorbent regeneration will probably not be used in first generation plants. When sorbent regeneration is used, the flue gases will be treated to recover sulfur.

To achieve economically competitive performance, flue gases from the combustor must be expanded through a gas turbine. Two options exist. The first option, similar to the Miniplant, is to use two or three stages of cyclones to reduce particulates to 22-65 ng/J (0.05-0.15 lb/10^6 Btu).* The flue gases would be expanded through a low pressure ratio, heavy-duty turbine to recover electricity. Final particulate control would probably be needed to meet environmental standards. In this first case, inputs to the process would be coal and sorbent, solid wastes would be spent bed material, cyclone catches and fabric filter, or ESP catch. Particulates emitted to the atmosphere would represent 20 percent or less (12.9 ng/J [0.03 lb/10^6 Btu]) of the material entering the fabric filter or ESP. Flue gas flow rates would be similar to those for conventional combustion systems.

The second option would consist of better high temperature/high pressure particulate control. If the particulate concentration can be reduced to 1-20 mg/m^3 equivalent to an emission rate less than that required by environmental standards) a higher performance gas turbine can be used to improve fuel-to-electricity efficiency. In this case a final low temperature, 175°-350°C (350°-700°F) control device would not be used, and emissions would consist of smaller quantities of particulates not collected at 800°C (1500°F) and 1000 kPa (10 atm).

Data in Table 55 indicate that most of the radioisotopes leave the system as part of the combustor cyclone catches. Radioisotopes escaping the plant in the flue gases at Exxon or in a commercial FBC facility would probably be 1 to 20 percent of that measured in the ESP hopper catch.

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*During the tests described in this report, particulate emissions were 60-80 mg/J (0.14-0.20 lb/10^6 Btu) and the concentration was in the 180-230 mg/m^3 range.

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APPENDIX A

LEVEL 1 LABORATORY ORGANIC ANALYSIS RESULTS

DILUTED COMBUSTOR FLUE GAS ORGANIC MODULE

CH_2Cl_2 Extract, Day 3, EX1-3-01-XM

Extractable Organics:

TCO = 3,700 μg

GRAV = 65,000 μg

TOTAL = 2,200 $\mu g/m^3$

Infrared Analysis:

Aliphatic hydrocarbons, esters, acids, or alcohols may be present.

Low Resolution Mass Spectrometry:

See detailed Liquid Chromatography Results.

Liquid Chromatography

Quantity taken for LC: 2700 μg TCO, 41,000 μg GRAV, 63% Total

Fraction	TCO (μg)	GRAV (μg)	Total (μg)	Total ($\mu g/m^3$)
1	960	64,000	65,000	2,100
2	54	1,300	1,400	44
3	280	240	510	16
4	250	650	900	29
5	60	530	590	19
6	130	-[a]	130	40
7	110	8,600	8,700	280
TOTAL	1,800	76,000	78,000	2,500

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[a] Less than blank

DILUTED COMBUSTOR FLUE GAS ORGANIC MODULE

CH_2Cl_2 Extract, Day 3, EX1-3-01-XM

LC1

Extractable Organics:

TCO = 960 μg
GRAV = 64,000 μg
TOTAL = 2,100 $\mu g/m^3$

Infrared Analysis:

Compound Class	Comments
Saturated aliphatic hydrocarbons	None

Low Resolution Mass Spectrometry:

Major Categories Present	Assigned Intensity/Concentration
Aliphatic hydrocarbons	100 / 2100 $\mu g/m^3$

Subcategories, Specific Compounds	Assigned Intensity/Concentration
None identified	---

DILUTED COMBUSTOR FLUE GAS ORGANIC MODULE

CH_2Cl_2 Extract, Day 3, EX1-3-01-XM

LC2

Extractable Organics:

TCO	=	54 µg
GRAV	=	1300 µg
TOTAL	=	44 $\mu g/m^3$

Infrared Analysis:

Compound Class	Comments
Saturated aliphatic hydrocarbons	
Unsaturated aliphatics	Trace

Low Resolution Mass Spectrometry:

LRMS not conducted

DILUTED COMBUSTOR FLUE GAS ORGANIC MODULE

CH_2Cl_2 Extract, Day 3, EX1-3-01-XM

LC3

Extractable Organics:

TCO = 280 µg

GRAV = 240 µg

TOTAL = 16 µg/m^3

Infrared Analysis:

Compound Class	Comments
Aliphatic hydrocarbons	

Low Resolution Mass Spectrometry:

LRMS not conducted

DILUTED COMBUSTOR FLUE GAS ORGANIC MODULE

CH_2Cl_2 Extract, Day 3, EX1-3-01-XM

LC4

Extractable Organics:

TCO = 250 μg
GRAV = 650 μg
TOTAL = 29 $\mu g/m^3$

Infrared Analysis:

Compound Class	Comments
None identified	

Low Resolution Mass Spectrometry:

LRMS not conducted

DILUTED COMBUSTOR FLUE GAS ORGANIC MODULE

CH_2Cl_2 Extract, Day 3, EX1-3-01-XM

LC5

Extractable Organics:

TCO = 60 μg

GRAV = 530 μg

TOTAL = 19 $\mu g/m^3$

Infrared Analysis:

Compound Class	Comments
Aliphatic esters	

Low Resolution Mass Spectrometry:

LRMS not conducted

DILUTED COMBUSTOR FLUE GAS ORGANIC MODULE

CH_2Cl_2 Extract, Day 3, EX1-3-01-XM

LC6

Extractable Organics:

TCO = 130 μg
GRAV = less than blank
TOTAL = 40 $\mu g/m^3$

Infrared Analysis:

Compound Class	Comments
Esters	
Acids	
Aliphatics	
Aromatics	

Low Resolution Mass Spectrometry:

LRMS not conducted

DILUTED COMBUSTOR FLUE GAS ORGANIC MODULE

CH_2Cl_2 Extract, Day 3, EX1-3-01-XM

LC7

Extractable Organics:

TCO	=	110 μg
GRAV	=	8600 μg
TOTAL	=	280 μg/m^3

Infrared Analysis:

Compound Class	Comments
Acids	
Esters	
Aliphatic groups	
Anomatic groups	

Low Resolution Mass Spectrometry:

LRMS not conducted

DILUTED COMBUSTOR FLUE GAS COARSE PARTICULATE

CH_2Cl_2 Extract, Day 3, EX1-3-01-CC

Extractable Organics:

TCO	=	not determined
GRAV	=	7,300 μg
TOTAL	=	230 $\mu g/m^3$
		25,000 μg/g

Infrared Analysis:

Compound Class	Comments
Alcohols	Possible
Substituted aliphatics	Predominant
Substituted aromatics	Weak

Low Resolution Mass Spectrometry:

Compound Class	Assigned Intensity/Concentration
Aliphatics C_{10}, C_{12}	100 / 210 $\mu g/m^3$
Phthalates	10 / 21 $\mu g/m^3$

Liquid Chromatography:

Sample quantity did not meet the Level 1 criteria for liquid chromatography.

DILUTED COMBUSTOR FLUE GAS FIVE PARTICULATE

CH_2Cl_2 Extract, Day 3, EX1-3-01-FC

Extractable Organics:

TCO = not determined
GRAV = no results - blank correction problem
TOTAL =

Infrared Analysis:

Compound Class	Comments
Aliphatic hydrocarbon	Weak

Low Resolution Mass Spectrometry:

Compound Class	Assigned Intensity/Concentration
Aliphatics C_{10}, C_{12}	100 / ---
Phthalates	10 / ---

Liquid Chromatography:

Sample quantity did not meet the Level 1 criteria for liquid chromatography.

ELECTROSTATIC PRECIPITATOR

CH_2Cl_2 Extract, EX1-3-01-FA

Extractable Organics:

TCO	=	660 µg
GRAV	=	4900 µg
TOTAL	=	785 µg/g

Infrared Analysis:

Compound Class	Comments
Esters	Present
Substituted aliphatics	Predominant
Substituted aromatics	Weak
Carboxylic acid	Possible

Low Resolution Mass Spectrometry:

Compound Class	Assigned Intensity/Concentration
Aliphatic C_{12}-C_{13}	100 / 778 µg/g
Phthalates	1 / 7.8 µg/g

Liquid Chromatography:

Sample quantity did not meet the Level 1 criteria for liquid chromatography.

UNDILUTED COMBUSTOR FLUE GAS ORGANIC MODULE

CH_2Cl_2 Extract, Day 1, EX1-1-02-XM

Extractable Organics:

TCO = 2,000 μg
GRAV = 11,000 μg
TOTAL = 390 $\mu g/m^3$

Infrared Analysis:

Compound Class	Comments
Esters	Present
Alcohols	Present
Substituted aliphatics	Present
Substituted aromatics	Present

Low Resolution Mass Spectrometry:

Compound Class	Assigned Intensity/Concentration
Sulfur	100 / 130 $\mu g/m^3$
Aliphatic	100 / 130 $\mu g/m^3$
Phthalates due to sample contamination	100 / not applicable

Liquid Chromatography:

Sample quantity did not meet the Level 1 criteria for liquid chromatography.

UNDILUTED COMBUSTOR FLUE GAS ORGANIC MODULE

CH_2Cl_2 Extract, Day 2, EX1-2-02-XM

Extractable Organics:

TCO = 260 μg
GRAV = 22,000 μg
TOTAL = 710 $\mu g/m^3$

Infrared Analysis:

Compound Class	Comments
Esters	Present
Carbonyl compounds	Possible
Alcohols	Present
Substituted aliphatics	Present
Substituted aromatics	Present

Low Resolution Mass Spectrometry:

Compound Class	Assigned Intensity/Concentration
Aliphatics	100 / 640 $\mu g/m^3$
Sulfur	10 / 64 $\mu g/m^3$

Liquid Chromatography:

Sample quantity was inadequate because 70 percent was used for bioassay.

BOLSTON FILTER

CH_2Cl_2 Extract, EX1-3-02-PBF

Extractable Organics:

TCO = Not Determined
GRAV = 340 μg
TOTAL = 307 μg/g

Infrared Analysis:

Compound Class	Comments
None identified	

Low Resolution Mass Spectrometry:

Compound Class	Assigned Intensity/Concentration
None identified	----

Liquid Chromatography:

Sample quantity did not meet the Level 1 criteria for liquid chromatography.

REGENERATOR FLUE GAS ORGANIC MODULE

CH_2Cl_2 Extract, Day 1, EX1-1-03-XM

Extractable Organics:

TCO = 35,000 μg
GRAV = 430,000 μg
TOTAL = 13,500 μg/m^3

Infrared Analysis:

Compound Class	Comments
Aliphatic hydrocarbons	All may be present
Esters	
Acids	
Alcohols	

Low Resolution Mass Spectrometry:

See detailed liquid chromatography.

Liquid Chromatography

Quantity taken for LC: 6,300 μg TCO, 83,000 μg GRAV, 19.5 % Total

Fraction	TCO (μg)	GRAV (μg)	Total (μg)	Total (μg/m^3)
1	8,800	140,000	150,000	4,300
2	510	48,000	49,000	1,400
3	7,800	120,000	130,000	3,700
4	95	4,500	4,600	130
5	180	2,900	3,100	89
6	270	2,500	2,800	80
7	130	2,200	2,300	67
TOTAL	18,000	320,000	340,000	9,800

REGENERATOR FLUE GAS ORGANIC MODULE

CH_2Cl_2 Extract, Day 1, EX1-1-03-XM

LC1

Extractable Organics:

TCO = 8,800 μg

GRAV = 140,000 μg

TOTAL = 4,400 $\mu g/m^3$

Infrared Analysis:

Compound Class	Comments
Aliphatic hydrocarbons	---
Aromatic hydrocarbons	Trace GRAV sample had the physical appearance of elemental sulfur

Low Resolution Mass Spectrometry:

Major Categories Present	Assigned Intensity/Concentration
Sulfur	100 / 4300 $\mu g/m^3$

Subcategories, Specific Compound	Assigned Intensity/Concentration
None identified	---

REGENERATOR FLUE GAS ORGANIC MODULE

CH_2Cl_2 Extract, Day 1, EX1-1-03-XM

LC2

Extractable Organics:

TCO = 510 μg
GRAV = 48,000 μg
TOTAL = 1,400 $\mu g/m^3$

Infrared Analysis:

Compound Class	Comments
Aromatic hydrocarbons	
	GRAV sample had the physical appearance of elemental sulfur

Low Resolution Mass Spectrometry:

Major Categories, Present	Assigned Intensity/Concentration
Sulfur	100 / 1400 $\mu g/m^3$
Aliphatic hydrocarbon	1 / 14 $\mu g/m^3$

Subcategories, Specific Compound	Assigned Intensity/Concentration
None identified	---

REGENERATOR FLUE GAS ORGANIC MODULE

CH_2Cl_2 Extract, Day 1, EX1-1-03-XM

LC3

Extractable Organics:

TCO = 7,800 μg
GRAV = 120,000 μg
TOTAL = 3,700 μg/m³

Infrared Analysis:

Compound Class	Comments
Aromatic hydrocarbons	
	GRAV sample had the physical appearance of elemental sulfur

Low Resolution Mass Spectrometry:

Major Categories, Present	Assigned Intensity/Concentration
Sulfur	100 / 3700 μg/m³
Polynuclear aromatic	1 / 37 μg/m³
Substituted PNA or heterocyclic sulfur	1 / 37 μg/m³

Subcategories, Specific Compound	Assigned Intensity/Concentration
None identified	---

REGENERATOR FLUE GAS ORGANIC MODULE

CH_2Cl_2 Extract, Day 1, EX1-1-03-XM

LC4

Extractable Organics:

TCO = 95 μg
GRAV = 4500 μg
TOTAL = 130 $\mu g/m^3$

Infrared Analysis:

Compound Class	Comments
Ester	Extremely weak

Low Resolution Mass Spectrometry:

LRMS not conducted

REGENERATOR FLUE GAS ORGANIC MODULE

CH_2Cl_2 Extract, Day 1, EX1-1-03-XM

LC5

Extractable Organics:

TCO = 180 μg

GRAV = 2900 μg

TOTAL = 89 $\mu g/m^3$

Infrared Analysis:

Compound Class	Comments
Esters	Extremely weak

Low Resolution Mass Spectrometry:

LRMS not conducted

REGENERATOR FLUE GAS ORGANIC MODULE

CH_2Cl_2 Extract, Day 1, EX1-1-03-XM

LC6

Extractable Organics:

TCO = 270 μg
GRAV = 2500 μg
TOTAL = 80 $\mu g/m^3$

Infrared Analysis:

Compound Class	Comments
Esters	
Ketones	
Aliphatic	
Aromatic	
Alcohols	Trace

Low Resolution Mass Spectrometry:

LRMS not conducted

REGENERATOR FLUE GAS ORGANIC MODULE

CH_2Cl_2 Extract, Day 1, EX1-1-03-XM

LC7

Extractable Organics:

TCO = 130 μg
GRAV = 2200 μg
TOTAL = 67 $\mu g/m^3$

Infrared Analysis:

Compound Class	Comments
Ketones	Extremely weak
Esters	Extremely weak

Low Resolution Mass Spectrometry:

LRMS not conducted

REGENERATOR FLUE GAS ORGANIC MODULE

CH_2Cl_2 Extract, Day 2, EX-1-2-03-XM

Extractable Organics:

TCO = 200,000 µg
GRAV = 370,000 µg
TOTAL = 17,000 $\mu g/m^3$

Infrared Analysis:

Compound Class	Comments
Aliphatic	Present
Aromatic	Present
Carbonyl compounds	Trace

Low Resolution Mass Spectrometry:

Compound Class	Assigned Intensity/Concentration	
Sulfur	100	/ 14,000 $\mu g/m^3$
Polynuclear aromatics	10	/ 1,400 $\mu g/m^3$
Aliphatics	10	/ 1,400 $\mu g/m^3$

Liquid Chromatography:

Not conducted on this sample. See Sample EX1-1-03-XM for results of the Day 1 regenerator flue gas sample.

DILUTION AIR ORGANIC MODULE

CH_2Cl_2 Extract, Day 1, EX1-1-04-XM

Extractable Organics:

TCO	=	1100 μg
GRAV	=	3900 μg
TOTAL	=	970 $\mu g/m^3$

Infrared Analysis:

Compound Class	Comments
Substituted aliphatics	Present
Substituted aromatics	Weak

Low Resolution Mass Spectrometry:

Compound Class	Assigned Intensity/Concentration
Aliphatics	100 / 970 $\mu g/m^3$

Liquid Chromatography:

Sample quantity did not meet the Level 1 criteria for liquid chromatography.

DILUTION AIR ORGANIC MODULE

CH_2Cl_2 Extract, Day 2, EX1-2-04-XM

Extractable Organics:

TCO = 1500 μg

GRAV = 1750 μg

TOTAL = 650 $\mu g/m^3$

Infrared Analysis:

Compound Class	Comments
Aliphatic	Present

Low Resolution Mass Spectrometry:

Compound Class	Assigned Intensity/Concentration
Aliphatics	100 / 650 $\mu g/m^3$

Liquid Chromatography:

Sample quantity did not meet the Level 1 criteria for liquid chromatography.

REGENERATOR CYCLONE CATCH

CH_2Cl_2 Extract, EX1-1-05-FAR

Extractable Organics:

TCO = 2200 μg
GRAV = 6900 μg
TOTAL = 71 μg/g

Infrared Analysis:

Compound Class	Comments
Aromatic hydrocarbons	Possible

Low Resolution Mass Spectrometry:

Compound Class	Assigned Intensity/Concentration	
Sulfur	100	/ 70 μg/g
Aliphatic	1	/ 0.7 μg/g

Liquid Chromatography:

Sample quantity did not meet the Level 1 criteria for liquid chromatography.

COMBUSTER BED

CH_2Cl_2 Extract, EX1-1-06-CB

Extractable Organics:

TCO = 96 µg

GRAV = 1800 µg

TOTAL = 19 µg/g

Infrared Analysis:

Compound Class	Comments
Aliphatic hydrocarbons	Present

Low Resolution Mass Spectrometry:

Compound Class	Assigned Intensity/Concentration
Aliphatic	100 / 19 µg/g

Liquid Chromatography:

Sample quantity did not meet the Level 1 criteria for liquid chromatography.

COMBUSTER SECOND CYCLONE CATCH

CH_2Cl_2 Extract, EX1-1-07-FA_2

Extractable Organics:

TCO = 300 μg
GRAV = less than blank
TOTAL = 3 μg/g

Infrared Analysis:

Compound Class	Comments
Contents of spectra less than blank	

Low Resolution Mass Spectrometry:

Compound Class	Assigned Intensity/Concentration
Not analyzed because of low organic residue.	

Liquid Chromatography:

Sample quantity did not meet the Level 1 criteria for liquid chromatography.

COMBUSTOR THIRD CYCLONE CATCH

CH_2Cl_2 Extract, EX1-1-08-FA_3

Extractable Organics:

TCO = 165 µg
GRAV = less than blank
TOTAL = 1.65 µg/g

Infrared Analysis:

Compound Class	Comments
Contents of spectra less than blank	

Low Resolution Mass Spectrometry:

Compound Class	Assigned Intensity/Concentration

Not analyzed because of low organic residue.

Liquid Chromatography:

Sample quantity did not meet the Level 1 criteria for liquid chromatography.

COAL FEED

CH_2Cl_2 Extract, EX1-1-09-CF

Extractable Organics:

TCO	=	48,000 μg
GRAV	=	170,000 μg
TOTAL	=	2,200 μg/g

Infrared Analysis:

Compound Class	Comments
Esters	Weak
Alcohols	Possible
Substituted aliphatics	Present
Substituted aromatics (possibly including N-Heterocyclics)	Present
Carbocylic acids	Possible

Low Resolution Mass Spectrometry:

Compound Class	Assigned Intensity/Concentration	
Aliphatics	100	---

Only aliphatics could be identified from a complex mixture. Other compound classes could not be adequately characterized.

Liquid Chromatography:

Not conducted.

SORBENT FEED

CH_2Cl_2 Extract, EX1-1-10-SF

Extractable Organics:

TCO = 96 μg
GRAV = 14,000 μg
TOTAL = 15 μg/g

Infrared Analysis:

Compound Class	Comments
Spectral content less than blank	

Low Resolution Mass Spectrometry:

Compound Class	Assigned Intensity/Concentration	
Aliphatic	100	/ 15 μg
Sulfur	1	/ 0.15 μg/g

Liquid Chromatography:

Sample quantity did not meet the Level 1 criteria for liquid chromatography.

SITE F01:   VOLUME SAMPLED=34.33DSCM

EX1-1-03 (REGENERATOR FLUE GAS)

ELEMENT	10+3UM CYCLONE (MG)	1UM CYCLONE (MG)	FILTER CATCH (MG)	XAD RESIN (MG)	COMPOSITE SAMPLE (MG)	TOTAL SASS (MG)	EMISSION FOUND (MG/DSCM)
RU	< 0.0002	< 0.0001	< 0.0001	0.042	< 0.047	0.042	0.0012
MO	0.29	0.014	0.25	0.058	0.20	0.85	0.025
NB	0.0100	0.0005	0.0002	0.0049	< 0.0054	0.016	0.0005
ZR	0.029	0.0012	< 0.0013	0.013	0.020	0.064	0.0019
Y	0.0053	0.0003	< 0.0001	< 0.0010	< 0.0084	0.0056	0.0002
SR	0.050	0.0049	0.0020	< 0.083	0.0100	0.067	0.0020
RB	0.0037	< 0.0001	< 0.0003	0.0023	< 0.0025	0.0060	0.0002
BR	0.13	0.0058	< 0.0001	< 0.031	< 0.062	0.14	0.0040
SE	0.092	0.0045	0.0100	0.036	0.20	0.34	0.0099
AS	0.027	0.0051	0.0100	0.0088	0.0098	0.061	0.0018
GE	0.011	0.0006	< 0.0001	< 0.0021	< 0.017	0.012	0.0003
GA	0.0039	0.0006	< 0.0001	< 0.0009	< 0.0071	0.0045	0.0001
ZN	0.049	0.0048	< 0.073	0.45	0.44	0.94	0.027
CU	0.28	0.014	0.052	1.9	0.084	2.4	0.069
NI	MC	1.2	1.1	< 1.8	0.42	-	-
CO	0.18	0.013	0.015	0.019	0.0100	0.24	0.0071
FE	MC	MC	4.2	0.81	< 5.7	-	-
MN	0.26	0.076	0.094	0.037	0.077	0.54	0.016
CR	1.5	0.31	0.85	0.30	0.78	3.7	0.11
V	0.050	0.0099	0.0064	0.0040	0.0077	0.078	0.0023
TI	0.15	0.049	0.017	< 0.088	< 0.099	0.22	0.0064
SC	0.0008	0.0002	< 0.0001	< 0.0007	< 0.0025	0.0010 TO 0.0042	< 0.0001 TO 0.0001
CA	11.	0.50	< 1.9	< 3.2	1.4	12.	0.36
K	0.041	0.016	0.17	< 1.3	< 0.31	0.23 TO 1.6	0.0067 TO 0.046
S	MC	MC	MC	< 34.	420.	-	-
P	0.019	0.015	< 0.034	< 0.48	< 0.24	0.034 TO 0.75	0.0010 TO 0.022
SI	3.4	0.11	< 0.26	< 2.0	< 3.7	3.5	0.10
AL	MC	0.35	0.84	< 1.6	0.75	-	-
MG	0.070	0.0068	< 0.20	< 1.4	< 0.17	0.077 TO 1.8	0.0022 TO 0.052
NA	0.022	0.0043	< 0.021	< 1.2	1.0	1.0	0.030
F	0.72	0.28	< 0.0078	0.058	< 0.12	1.1	0.031
B	0.022	0.0044	< 0.050	< 0.17	< 0.023	0.027 TO 0.24	0.0008 TO 0.0070
BE	0.0002	< 0.0001	< 0.0001	< 0.0007	0.011	0.011	0.0003
LI	0.0013	< 0.0001	< 0.0001	< 0.0017	< 0.0010	0.0015 TO 0.0033	< 0.0001 TO 0.0001

MC INDICATES A MAJOR COMPONENT OF THE SAMPLE.

- INDICATES THAT THE TOTAL AND EMISSION VALUES WERE NOT CALCULATED OWING TO THE PRESENCE OF AN MC CONCENTRATION.

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SITE F01: VOLUME SAMPLED=34.33DSCM

Ex1-1-03 (REGENERATOR FLUE GAS)

ELEMENT	10+3UM CYCLONE (MG)	1UM CYCLONE (MG)	FILTER CATCH (MG)	XAD RESIN (MG)	COMPOSITE SAMPLE (MG)	TOTAL MASS (MG)	EMISSION FOUND (MG/DSCM)
U	< 0.0003	< 0.0001	< 0.0001	< 0.0070	< 0.063	< 0.071	< 0.0021
TH	< 0.0004	< 0.0001	< 0.0002	< 0.011	< 0.091	< 0.109	< 0.0032
BI	0.0012	< 0.0001	0.0004	< 0.0034	< 0.028	0.0016 TO 0.032	< 0.0001 TO 0.0009
PB	0.096	0.0013	0.030	< 0.21	< 0.054	0.13 TO 0.27	0.0037 TO 0.0079
TL	0.0033	< 0.0001	< 0.0001	< 0.0042	< 0.035	0.0033 TO 0.040	< 0.0001 TO 0.0012
AU	< 0.0002	< 0.0001	< 0.0001	< 0.0057	< 0.047	< 0.053	< 0.0015
IR	< 0.0003	< 0.0001	< 0.0001	< 0.0067	< 0.073	< 0.082	< 0.0024
OS	< 0.0004	< 0.0001	< 0.0002	< 0.0095	< 0.079	< 0.089	< 0.0026
RE	< 0.0002	< 0.0001	< 0.0001	< 0.0060	< 0.050	< 0.055	< 0.0016
W	0.0024	0.0005	< 0.0001	< 0.0080	< 0.067	0.0029 TO 0.075	< 0.0001 TO 0.0022
HF	0.0010	< 0.0003	< 0.0002	< 0.0100	< 0.083	0.0010 TO 0.094	< 0.0001 TO 0.0027
LU	< 0.0002	< 0.0001	< 0.0001	< 0.0025	< 0.020	< 0.022	< 0.0006
YB	< 0.0001	< 0.0001	< 0.001	< 0.0034	< 0.026	< 0.032	< 0.0009
TM	< 0.0001	< 0.0001	< 0.0001	< 0.0021	< 0.017	< 0.020	< 0.0006
ER	< 0.0002	< 0.0001	< 0.0001	< 0.0061	< 0.051	< 0.058	< 0.0017
HO	< 0.0001	< 0.0001	< 0.0001	< 0.0020	< 0.017	< 0.0001 TO 0.019	< 0.0001 TO 0.0005
DY	0.0003	< 0.0001	< 0.0001	< 0.0035	< 0.029	0.0003 TO 0.033	< 0.0001 TO 0.0010
TB	< 0.0001	< 0.0001	< 0.0001	< 0.0009	< 0.0079	< 0.0089	< 0.0003
GD	0.0001	< 0.0001	< 0.0001	< 0.0035	< 0.029	0.0001 TO 0.033	< 0.0001 TO 0.0009
EU	< 0.0001	< 0.0001	< 0.0001	< 0.0016	< 0.013	< 0.015	< 0.0004
SM	0.0006	< 0.0001	< 0.0001	< 0.0061	< 0.051	0.0006 TO 0.057	< 0.0001 TO 0.0017
ND	0.0050	< 0.0001	< 0.0001	< 0.0076	< 0.063	0.0051 TO 0.071	0.0001 TO 0.0021
PR	0.0008	< 0.0001	< 0.0001	< 0.0013	< 0.011	0.0008 TO 0.015	< 0.0001 TO 0.0004
CE	0.0022	0.0004	0.0001	0.014	< 0.015	0.016	0.0005
LA	0.0022	0.0002	< 0.0001	0.0039	< 0.016	0.0064 TO 0.016	0.0002 TO 0.0005
BA	0.020	0.0025	< 0.023	< 0.061	< 0.064	0.025 TO 0.17	0.0007 TO 0.0049
CS	< 0.0001	< 0.0001	< 0.0001	< 0.0067	< 0.026	0.001 TO 0.034	< 0.0001 TO 0.0010
I	< 0.0027	< 0.0001	< 0.0002	0.021	< 0.067	0.021 TO 0.090	0.0006 TO 0.0026
TE	0.084	0.0005	0.0026	< 0.0044	< 0.037	0.088	0.0026
SB	0.0037	0.0003	0.0004	< 0.0031	< 0.025	0.0043 TO 0.028	0.0001 TO 0.0008
SN	0.0022	0.0006	0.0043	0.066	< 0.54	0.073 TO 0.54	0.0021 TO 0.016
CD	0.0096	0.0002	0.011	0.0094	< 0.045	0.030	0.0009
PD	< 0.0002	< 0.0001	< 0.0001	< 0.0044	< 0.036	< 0.041	< 0.0012
RH	< 0.0001	< 0.0001	0.0001	0.092	< 0.013	0.092	0.0027

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SITE F021   VOLUME SAMPLED=31.47DSCM

EX1-3-01 (COMBUSTOR FLUE GAS)

ELEMENT	PR SOLIDS (MG)	10+3UM CYCLONE (MG)	1UM CYCLONE (MG)	FILTER CATCH (MG)	XAD RESIN (MG)	COMPOSITE SAMPLE (MG)	TOTAL SASS (MG)	EMISSION FOUND (MG/DSCM)
U	0.0049	0.0017	0.0061	0.0032	< 0.0074	< 0.0046	0.016	0.0005
TH	0.028	0.0068	0.049	0.017	< 0.011	< 0.012	0.10	0.0032
BI	0.0015	0.0004	0.0027	0.0014	< 0.0033	< 0.0039	0.0060	0.0002
PB	0.062	< 0.0001	0.13	< 0.052	< 0.21	0.053	0.25	0.0079
TL	0.068	0.034	0.20	< 0.0009	< 0.0041	< 0.0048	0.30	0.0095
AU	< 0.0003	< 0.0001	< 0.0007	< 0.0012	< 0.0055	< 0.0064	< 0.014	< 0.0004
IR	< 0.0008	< 0.0001	< 0.0011	< 0.0018	< 0.0085	< 0.0099	< 0.022	< 0.0007
OS	< 0.0005	< 0.0001	0.0013	< 0.0020	< 0.0092	< 0.011	0.0013 TO 0.023	< 0.0001 TO 0.0007
RE	< 0.0003	0.0001	0.0069	0.0051	< 0.0058	< 0.0068	0.0061 TO 0.013	0.0002 TO 0.0004
W	0.0004	< 0.0001	0.0007	0.013	< 0.0078	< 0.0092	0.014	0.0004
HF	0.0054	0.0013	0.0065	< 0.0027	< 0.0098	< 0.011	0.013	0.0004
LU	0.0014	0.0002	0.0018	0.0005	< 0.0023	< 0.0027	0.0039	0.0001
YB	0.0027	0.0010	0.0036	0.0078	< 0.0033	< 0.0039	0.015	0.0005
TM	0.0008	0.0003	0.0014	0.0004	< 0.0020	< 0.0024	0.0030	< 0.0001
ER	0.0069	0.0014	0.014	0.0046	< 0.0060	< 0.0070	0.027	0.0009
HO	0.0004	0.0003	0.0010	0.0017	< 0.0020	< 0.0023	0.0033	0.0001
DY	0.012	0.0013	0.0095	0.0021	< 0.0034	< 0.0040	0.025	0.0008
TB	0.0005	0.0001	0.0005	0.012	< 0.0009	< 0.0011	0.013	0.0004
GD	0.0045	0.0009	0.0014	< 0.0093	< 0.0034	< 0.0040	0.0068 TO 0.017	0.0002 TO 0.0005
EU	0.0010	0.0005	0.0025	< 0.0050	< 0.0015	< 0.0018	0.0040 TO 0.0084	0.0001 TO 0.0003
SM	0.011	0.0033	0.028	< 0.039	< 0.0059	< 0.0069	0.042	0.0013
ND	0.049	0.013	0.069	0.046	< 0.0074	< 0.0087	0.19	0.0061
PR	0.0082	0.0041	0.021	0.0082	< 0.0013	< 0.0015	0.041	0.0013
CE	0.093	0.046	0.23	0.089	< 0.0018	< 0.0021	0.46	0.015
LA	0.093	0.033	0.33	0.047	< 0.0019	< 0.0022	0.50	0.016
BA	0.44	0.21	1.1	< 42.	< 0.055	0.0061	1.7 TO 42.	0.055 TO 1.3
CS	0.0019	0.0005	0.0046	0.0007	< 0.0007	< 0.0004	0.0074	0.0002
I	< 0.0010	< 0.0003	< 0.0022	0.0011	0.020	< 0.048	0.021 TO 0.052	0.0007 TO 0.0016
TE	0.0021	< 0.0001	0.0010	0.0008	< 0.0043	< 0.0050	0.0040 TO 0.0093	0.0001 TO 0.0003
SB	0.0047	0.0008	0.0079	0.0005	< 0.0030	< 0.0035	0.014	0.0004
SN	0.0053	0.0013	0.015	0.0054	< 0.046	< 0.039	0.027 TO 0.065	0.0008 TO 0.0021
CD	0.0017	0.0002	0.0016	< 0.034	< 0.0053	< 0.0062	0.0036 TO 0.045	0.0001 TO 0.0014
PD	0.0015	0.0001	0.0011	< 0.0009	< 0.0043	< 0.0050	0.0027 TO 0.0100	< 0.0001 TO 0.0003
RH	< 0.0002	< 0.0001	0.0001	< 0.0005	< 0.0015	< 0.0017	0.0001 TO 0.0037	< 0.0001 TO 0.0001

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SITE F028   VOLUME SAMPLED=31.47DSCM

EX1-5-01 (COMBUSTOR FLUE GAS)

ELEMENT	PR SOLIDS (MG)	10+3UM CYCLONE (MG)	1UM CYCLONE (MG)	FILTER CATCH (MG)	XAD RESIN (MG)	COMPOSITE SAMPLE (MG)	TOTAL SASS (MG)	EMISSION FOUND (MG/DSCM)
PB	0.0006	0.0001	0.0039	< 0.0012	< 0.0055	< 0.0066	[illegible] TO [illegible]	< [illegible] TO [illegible]
MO	0.0056	0.0063	0.011	0.017	0.071	0.36	0.47	0.015
NB	0.027	0.0066	0.067	0.0016	< 0.0067	0.0015	0.10	0.0033
ZR	0.30	0.075	0.68	0.058	< 0.0066	0.011	1.1	0.036
Y	0.056	0.055	0.28	0.070	< 0.0010	< 0.0011	0.40	0.013
SR	1.1	0.38	2.7	< 4.4	< 0.024	< 0.0057	4.1	0.13
RB	0.039	0.010	0.097	< 0.065	< 0.0045	< 0.0004	0.15	0.0048
BR	0.017	0.0057	0.045	0.096	0.084	< 0.071	0.25	0.0079
SE	0.12	0.026	0.095	0.21	< 0.091	0.025	0.47	0.015
AS	0.039	0.0085	0.086	< 0.030	< 0.0035	0.0019	0.13	0.0042
GE	0.0049	0.0005	0.017	0.0021	< 0.0020	< 0.0024	0.025	0.0008
GA	0.021	0.0080	0.052	0.027	< 0.0008	0.0039	0.11	0.0036
ZN	0.063	0.031	0.13	< 52.	< 0.37	< 0.070	0.22 TO 53.	0.0071 TO 1.7
CU	0.044	0.025	0.084	0.081	< 0.24	0.019	0.25	0.0080
NI	0.19	0.19	0.66	0.16	< 0.59	11.	12.	0.39
CO	0.022	0.021	0.054	0.044	< 0.012	0.057	0.20	0.0065
FE	15.	MC	MC	12.	< 2.7	63.	-	-
MN	0.044	0.043	0.16	< 0.22	0.021	1.6	1.9	0.061
CR	0.063	0.089	0.31	0.16	0.40	20.	21.	0.67
V	0.13	0.065	0.64	0.15	< 0.0055	0.0061	0.99	0.031
TI	4.3	2.3	7.9	3.2	< 0.016	0.020	18.	0.58
CA	58.	MC	MC	< 80.	< 3.4	< 0.15	-	-
K	0.84	0.87	6.2	< 7.4	< 0.51	< 0.021	7.9	0.25
S	20.	MC	MC	150.	21.	110.	-	-
P	0.20	0.26	2.9	0.76	< 0.22	< 0.033	4.1	0.13
SI	4.0	MC	MC	0.74	< 3.6	< 1.7	-	-
AL	1.6	< 0.032	3.9	< 12.	< 0.29	< 0.12	5.5 TO 18.	0.17 TO 0.58
MG	0.36	0.35	2.5	< 4.2	< 0.65	< 0.004	[illegible] TO 10.	[illegible] TO 0.32
NA	0.044	0.066	1.4	< 0.26	< 0.84	< 0.37	1.5	0.047
F	0.12	0.12	0.83	< 0.78	< 0.054	< 0.017	1.1	0.034
B	0.088	0.029	0.42	< 57.	< 0.0070	< 0.0032	.54 TO 58.	0.017 TO 1.8
BE	0.0018	0.0005	0.0092	0.0090	< 0.0007	< 0.0004	0.020	0.0006
LI	0.0065	0.0032	0.067	0.089	< 0.0008	< 0.0001	0.17	0.0055

MC INDICATES A MAJOR COMPONENT OF THE SAMPLE.

- INDICATES THAT THE TOTAL AND EMISSION VALUES WERE NOT CALCULATED OWING TO THE PRESENCE OF AN MC CONCENTRATION.

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APPENDIX B

PTSAMIA OUTPUT

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                         EX1-S-01  REGEN FLUE GAS

               SUBTOTAL INORGANIC DISCHARGE SEVERITY FROM THE EFFLUENT STREAM :


SUBTOTAL DISCHARGE SEVERITY (HEALTH DMEG BASED) =      4.104E+05
SUBTOTAL DISCHARGE SEVERITY (ECOL DMEG BASED) =       $1.000E+00

               SUBTOTAL INORGANIC WEIGHTED DISCHARGE SEVERITY FROM THE EFFLUENT STREAM :


SUBTOTAL WEIGHTED DISCHARGE SEVERITY (HEALTH DMEG BASED) =      < 1.847E+02
SUBTOTAL WEIGHTED DISCHARGE SEVERITY (ECOLOGICAL DMEG BASED) =  < 1.595E+00
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POLLUTANT        DISCHARGE          AIR  DMEG              IF       DISCHARGE SEVERITY             WEIGHTED
 SPECIES       CONCENTRATION                              DMEG                                     DISCHARGE
                                                        EXCEEDED                                   SEVERITY
                               (HEALTH)   (ECOLOGICAL)  (H)  (E)  (HEALTH)      (ECOLOGICAL)    (HEALTH)   (ECOLOGICAL)


                        3                     3
        (MICROGRAMS/METER ) (MICROGRAMS/METER )                                                  (METERS*3/SEC.)


RHODIUM           1.000E-01   1.000E+00   **NA/ND**    NO   ***   1.000E-01     **NA/ND**     4.500E-03     **NA/ND**
PALLADIUM         3.000E-01   **NA/ND**   **NA/ND**    ***  ***   **NA/ND**     **NA/ND**     **NA/ND**     **NA/ND**
CADMIUM           1.400E+00   1.000E+01   **NA/ND**    NO   ***   1.400E-01     **NA/ND**     6.300E-03     **NA/ND**
INDIUM          NOT FOUND AS INPUT
TIN               2.700E+00   **NA/ND**   **NA/ND**    ***  ***   **NA/ND**     **NA/ND**     **NA/ND**     **NA/ND**
ANTIMONY          4.000E-01   5.000E+02   **NA/ND**    NO   ***   8.000E-04     **NA/ND**     3.600E-05     **NA/ND**
TELLURIUM         3.000E-01   1.000E+02   **NA/ND**    NO   ***   3.000E-03     **NA/ND**     1.350E-04     **NA/ND**
IODINE            1.600E+00   **NA/ND**   **NA/ND**    ***  ***   **NA/ND**     **NA/ND**     **NA/ND**     **NA/ND**
CESIUM            2.000E-01   8.200E+04   **NA/ND**    NO   ***   2.439E-06     **NA/ND**     1.098E-07     **NA/ND**
BARIUM            1.300E+03   5.000E+02   **NA/ND**    YES  ***   2.600E+00     **NA/ND**     1.170E-01     **NA/ND**
LANTHANUM         1.600E+01   1.100E+05   **NA/ND**    NO   ***   1.455E-04     **NA/ND**     6.545E-06     **NA/ND**
CERIUM            1.500E+01   3.700E+04   **NA/ND**    NO   ***   4.054E-04     **NA/ND**     1.824E-05     **NA/ND**
PRASEODYMIUM      1.300E+00   5.100E+04   **NA/ND**    NO   ***   2.549E-05     **NA/ND**     1.147E-06     **NA/ND**
NEODYMIUM         6.100E+00   **NA/ND**   **NA/ND**    ***  ***   **NA/ND**     **NA/ND**     **NA/ND**     **NA/ND**
SAMARIUM          1.300E+00   5.500E+04   **NA/ND**    NO   ***   2.455E-05     **NA/ND**     1.104E-06     **NA/ND**
EUROPIUM          3.000E-01   **NA/ND**   **NA/ND**    ***  ***   **NA/ND**     **NA/ND**     **NA/ND**     **NA/ND**
GADOLINIUM        5.000E-01   **NA/ND**   **NA/ND**    ***  ***   **NA/ND**     **NA/ND**     **NA/ND**     **NA/ND**
TERBIUM           4.000E-01   **NA/ND**   **NA/ND**    ***  ***   **NA/ND**     **NA/ND**     **NA/ND**     **NA/ND**
DYSPROSIUM        8.000E-01   9.300E+03   **NA/ND**    NO   ***   8.602E-05     **NA/ND**     3.871E-06     **NA/ND**
HOLIMIUM          1.000E-01   **NA/ND**   **NA/ND**    ***  ***   **NA/ND**     **NA/ND**     **NA/ND**     **NA/ND**
ERBIUM            9.000E-01   **NA/ND**   **NA/ND**    ***  ***   **NA/ND**     **NA/ND**     **NA/ND**     **NA/ND**
THULIUM         < 1.000E-01   **NA/ND**   **NA/ND**    ***  *** < **NA/ND**   < **NA/ND**   < **NA/ND**   < **NA/ND**
YTTERBIUM         5.000E-01   1.000E+03   **NA/ND**    NO   ***   5.000E-04     **NA/ND**     2.250E-05     **NA/ND**
LUTETIUM          1.000E-01   **NA/ND**   **NA/ND**    ***  ***   **NA/ND**     **NA/ND**     **NA/ND**     **NA/ND**
HAFFNIUM          4.000E-01   5.000E+02   **NA/ND**    NO   ***   8.000E-04     **NA/ND**     3.600E-05     **NA/ND**
TUNGSTEN          4.000E-01   1.000E+03   **NA/ND**    NO   ***   4.000E-04     **NA/ND**     1.800E-05     **NA/ND**
RHENIUM           4.000E-01   **NA/ND**   **NA/ND**    ***  ***   **NA/ND**     **NA/ND**     **NA/ND**     **NA/ND**
OSMIUM            7.000E-01   **NA/ND**   **NA/ND**    ***  ***   **NA/ND**     **NA/ND**     **NA/ND**     **NA/ND**
IRIDIUM         < 7.000E-01   **NA/ND**   **NA/ND**    ***  *** < **NA/ND**   < **NA/ND**   < **NA/ND**   < **NA/ND**
GOLD            < 4.000E-01   **NA/ND**   **NA/ND**    ***  *** < **NA/ND**   < **NA/ND**   < **NA/ND**   < **NA/ND**
THALLIUM          9.500E+00   1.000E+02   **NA/ND**    NO   ***   9.500E-02     **NA/ND**     4.275E-03     **NA/ND**
LEAD              7.900E+00   1.500E+02   **NA/ND**    NO   ***   5.267E-02     **NA/ND**     2.370E-03     **NA/ND**
BISMUTH           2.000E-01   4.100E+02   **NA/ND**    NO   ***   4.878E-04     **NA/ND**     2.195E-05     **NA/ND**
THORIUM           3.200E+00   4.200E+02   **NA/ND**    NO   ***   7.619E-03     **NA/ND**     3.429E-04     **NA/ND**
URANIUM           5.000E-01   9.000E+00   **NA/ND**    NO   ***   5.556E-02     **NA/ND**     2.500E-03     **NA/ND**
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                                    EXI-[illegible]-0[illegible]  REGEN FLUE GAS

               N.B.  POLLUTANT CONCENTRATIONS ARE QUOTED IN PARTS PER MILLION BY WEIGHT, THESE HAVE BEEN CONVERTED
                     TO MICROGRAMS PER CUBIC METER OF FLUE GAS


                          ( **NA/ND** DENOTES DATA NOT AVAILBLE OR NOT DETERMINED )

 POLLUTANT          DISCHARGE           AIR  DMEG              IF         DISCHARGE SEVERITY               WEIGHTED
 SPECIES          CONCENTRATION                               DMEG                                         DISCHARGE
                                                            EXCEEDED                                       SEVERITY
                                  (HEALTH)   (ECOLOGICAL)   (H)  (E)   (HEALTH)      (ECOLOGICAL)      (HEALTH)  (ECOLOGICAL)


                               3                    3
                (MICROGRAMS/METER ) (MICROGRAMS/METER )                                                 (METERS*3/SEC.)

 LITHIUM           5.300E+00   2.200E+01   **NA/ND**     NO   ***   2.409E-01     **NA/ND**      1.084E-02     **NA/ND**
 BERYLLIUM         6.000E-01   2.000E+00   **NA/ND**     NO   ***   3.000E-01     **NA/ND**      1.350E-02     **NA/ND**
 BORON             1.800E+03   3.100E+03   **NA/ND**     NO   ***   5.806E-01     **NA/ND**      2.613E-02     **NA/ND**
 FLUORINE          3.400E+01   2.500E+03   **NA/ND**     NO   ***   1.360E-02     **NA/ND**      6.120E-04     **NA/ND**
 SODIUM            4.700E+01   5.300E+04   **NA/ND**     NO   ***   8.868E-04     **NA/ND**      3.991E-05     **NA/ND**
 MAGNESIUM         3.200E+02   6.000E+03   **NA/ND**     NO   ***   5.333E-02     **NA/ND**      2.400E-03     **NA/ND**
 ALUMINIUM         3.800E+02   5.200E+03   **NA/ND**     NO   ***   7.308E-02     **NA/ND**      3.288E-03     **NA/ND**
 SILICON           5.700E+02   1.000E+04   **NA/ND**     NO   ***   5.700E-02     **NA/ND**      2.565E-03     **NA/ND**
 PHOSPHORUS        1.300E+02   1.000E+02   **NA/ND**     YES  ***   1.300E+00     **NA/ND**      5.850E-02     **NA/ND**
 SULPHUR           1.010E+06   **NA/ND**   **NA/ND**     ***  ***   **NA/ND**     **NA/ND**      **NA/ND**     **NA/ND**
 CHLORINE        NOT FOUND AS INPUT
 POTASSIUM         2.500E+02   **NA/ND**   **NA/ND**     ***  ***   **NA/ND**     **NA/ND**      **NA/ND**     **NA/ND**
 CALCIUM(ION)      4.700E+06   1.600E+04   **NA/ND**     YES  ***   2.937E+02     **NA/ND**      1.322E+01     **NA/ND**
 TITANIUM          5.600E+02   6.000E+03   **NA/ND**     NO   ***   9.333E-02     **NA/ND**      4.200E-03     **NA/ND**
 VANADIUM          3.100E+01   5.000E+02   1.000E+00     NO   YES   6.200E-02     3.100E+01      2.790E-03     1.395E+00
 CHROMIUM          6.700E+02   1.000E+00   **NA/ND**     YES  ***   6.700E+02     **NA/ND**      3.015E+01     **NA/ND**
 MANGANESE         6.000E+01   5.000E+03   **NA/ND**     NO   ***   1.200E-02     **NA/ND**      5.400E-04     **NA/ND**
 IRON              3.100E+06   1.000E+03   **NA/ND**     YES  ***   3.100E+03     **NA/ND**      1.395E+02     **NA/ND**
 COBALT            6.300E+00   5.000E+01   **NA/ND**     NO   ***   1.260E-01     **NA/ND**      5.670E-03     **NA/ND**
 NICKEL            4.000E+02   1.500E+01   **NA/ND**     YES  ***   2.667E+01     **NA/ND**      1.200E+00     **NA/ND**
 COPPER            8.000E+00   2.000E+02   **NA/ND**     NO   ***   4.000E-02     **NA/ND**      1.800E-03     **NA/ND**
 ZINC              1.000E+03   4.000E+03   **NA/ND**     NO   ***   2.500E-01     **NA/ND**      1.125E-02     **NA/ND**
 GALLIUM           3.600E+00   5.000E+03   **NA/ND**     NO   ***   7.200E-04     **NA/ND**      3.240E-05     **NA/ND**
 GERMANIUM         8.000E-01   5.600E+02   **NA/ND**     NO   ***   1.429E-03     **NA/ND**      6.429E-05     **NA/ND**
 ARSENIC           1.500E+01   2.000E+00   **NA/ND**     YES  ***   7.500E+00     **NA/ND**      3.375E-01     **NA/ND**
 SELENIUM          1.500E+01   2.000E+02   **NA/ND**     NO   ***   7.500E-02     **NA/ND**      3.375E-03     **NA/ND**
 BROMINE           7.900E+00   **NA/ND**   **NA/ND**     ***  ***   **NA/ND**     **NA/ND**      **NA/ND**     **NA/ND**
 RUBIDIUM          4.800E+00   1.200E+05   **NA/ND**     NO   ***   4.000E-05     **NA/ND**      1.800E-06     **NA/ND**
 STRONTIUM         1.300E+02   3.100E+03   **NA/ND**     NO   ***   4.194E-02     **NA/ND**      1.887E-03     **NA/ND**
 YTTRIUM           1.500E+00   1.000E+03   **NA/ND**     NO   ***   1.500E-03     **NA/ND**      6.750E-05     **NA/ND**
 ZIRCONIUM         3.600E+01   5.000E+03   **NA/ND**     NO   ***   7.200E-03     **NA/ND**      3.240E-04     **NA/ND**
 NIOBIUM           3.300E+00   2.200E+04   **NA/ND**     NO   ***   1.500E-04     **NA/ND**      6.750E-06     **NA/ND**
 MOLYBDENUM        1.600E+01   5.000E+03   **NA/ND**     NO   ***   3.200E-03     **NA/ND**      1.440E-04     **NA/ND**
 RUTHENIUM         4.000E-01   **NA/ND**   **NA/ND**     ***  ***   **NA/ND**     **NA/ND**      **NA/ND**     **NA/ND**
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                    SAM / IA ANALYSIS :    INORGANIC EMISSIONS

SAM / IA, A SOURCE ANALYSIS MODEL ,WHICH IS BASED ON A COMPARISON OF DISCHARGE CONCENTRATIONS WITH A SET OF DISCHARGE
MULTIMEDIA ENVIRONMENTAL GOALS (MEG) CRITERIA ESTABLISHED BY THE U.S. E.P.A., IS USED FOR RAPID SCREENING OF EACH
DISCHARGE STREAM FROM FLUIDIZED BED COAL COMBUSTION PROCESS.

**************************************************************************************************************************

                                   BACKGROUND INFORMATION

PROCESS CHARACTERISTICS     SOURCE :                        EXXON MINIPLANT WITH REGENERATION

                            BED TEMPERATURE :               894 C

                            PRESSURE :                      760  KPA

                            BED HEIGHT :                    3.10 M

                            FLUIDIZING VELOCITY :           1.46 M/S

                            COAL TYPE :                     CHAMPION

                            SORBENT TYPE :                  GROVE LIMESTONE


SAMPLING CHARACTERISTICS    TEST DATE :                     MAY 4 1979

                            TEST NUMBER :                   03

                            SAMPLING GROUP(S) :

                            STREAM SAMPLED :                REGEN FLUE GAS

                            SAMPLING TECHNIQUE :            SASS TRAIN


STREAM CHARACTERISTICS      STREAM ANALYZED :               EX1-1-03  REGEN FLUE GAS

                            SAMPLE TYPE :                   TOTAL PART

                            ANALYTICAL TECHNIQUE :          SPARK SOURCE MASS SP

                            STREAM FLOW RATE :              4.500E-02     (CUBIC METER/SEC)

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POLLUTANT        DISCHARGE           AIR  DMEG              IF        DISCHARGE SEVERITY              WEIGHTED
 SPECIES       CONCENTRATION                               DMEG                                       DISCHARGE
                                                         EXCEEDED                                     SEVERITY
                               (HEALTH)   (ECOLOGICAL)  (H)  (E)  (HEALTH)     (ECOLOGICAL)      (HEALTH)  (ECOLOGICAL)


                            3                      3
              (MICROGRAMS/METER ) (MICROGRAMS/METER )                                               (METERS*3/SEC.)

RHODIUM         3.386E-04   1.000E+00   **NA/ND**   NO   ***  3.386E-04   **NA/ND**   7.899E-05   **NA/ND**
PALLADIUM       5.383E-03   **NA/ND**   **NA/ND**   ***  ***  **NA/ND**   **NA/ND**   **NA/ND**   **NA/ND**
CADMIUM         8.682E-03   1.000E+01   **NA/ND**   NO   ***  8.682E-04   **NA/ND**   2.026E-04   **NA/ND**
INDIUM          **NA/ND**   1.000E+02   **NA/ND**   ***  ***  **NA/ND**   **NA/ND**   **NA/ND**   **NA/ND**
TIN             4.688E-02   **NA/ND**   **NA/ND**   ***  ***  **NA/ND**   **NA/ND**   **NA/ND**   **NA/ND**
ANTIMONY        2.778E-02   5.000E+02   **NA/ND**   NO   ***  5.556E-05   **NA/ND**   1.296E-05   **NA/ND**
TELLURIUM       3.473E-03   1.000E+02   **NA/ND**   NO   ***  3.473E-05   **NA/ND**   8.102E-06   **NA/ND**
IODINE          5.383E-03   **NA/ND**   **NA/ND**   ***  ***  **NA/ND**   **NA/ND**   **NA/ND**   **NA/ND**
CESIUM          1.736E-02   8.200E+04   **NA/ND**   NO   ***  2.118E-07   **NA/ND**   4.940E-08   **NA/ND**
BARIUM          7.640E+00   5.000E+02   **NA/ND**   NO   ***  1.528E-02   **NA/ND**   3.565E-03   **NA/ND**
LANTHANUM       1.129E+00   1.100E+05   **NA/ND**   NO   ***  1.026E-05   **NA/ND**   2.394E-06   **NA/ND**
CERIUM          1.650E+00   3.700E+04   **NA/ND**   NO   ***  4.458E-05   **NA/ND**   1.040E-05   **NA/ND**
PRASEODYMIUM    1.476E-01   5.100E+04   **NA/ND**   NO   ***  2.894E-06   **NA/ND**   6.752E-07   **NA/ND**
NEODYMIUM       4.515E-01   **NA/ND**   **NA/ND**   ***  ***  **NA/ND**   **NA/ND**   **NA/ND**   **NA/ND**
SAMARIUM        1.129E-01   5.300E+04   **NA/ND**   NO   ***  2.130E-06   **NA/ND**   4.968E-07   **NA/ND**
EUROPIUM        1.736E-02   **NA/ND**   **NA/ND**   ***  ***  **NA/ND**   **NA/ND**   **NA/ND**   **NA/ND**
GADOLINIUM      3.299E-02   **NA/ND**   **NA/ND**   ***  ***  **NA/ND**   **NA/ND**   **NA/ND**   **NA/ND**
TERBIUM         4.601E-03   **NA/ND**   **NA/ND**   ***  ***  **NA/ND**   **NA/ND**   **NA/ND**   **NA/ND**
DYSPROSIUM      4.688E-02   9.300E+03   **NA/ND**   NO   ***  5.041E-06   **NA/ND**   1.176E-06   **NA/ND**
HOLMIUM         9.550E-03   **NA/ND**   **NA/ND**   ***  ***  **NA/ND**   **NA/ND**   **NA/ND**   **NA/ND**
ERBIUM          5.122E-02   **NA/ND**   **NA/ND**   ***  ***  **NA/ND**   **NA/ND**   **NA/ND**   **NA/ND**
THULIUM         9.550E-03   **NA/ND**   **NA/ND**   ***  ***  **NA/ND**   **NA/ND**   **NA/ND**   **NA/ND**
YTTERBIUM       3.473E-02   1.000E+03   **NA/ND**   NO   ***  3.473E-05   **NA/ND**   8.102E-06   **NA/ND**
LUTETIUM        8.682E-03   **NA/ND**   **NA/ND**   ***  ***  **NA/ND**   **NA/ND**   **NA/ND**   **NA/ND**
HAFFNIUM        4.515E-02   5.000E+02   **NA/ND**   NO   ***  9.029E-05   **NA/ND**   2.107E-05   **NA/ND**
TUNGSTEN        3.560E-03   1.000E+03   **NA/ND**   NO   ***  3.560E-06   **NA/ND**   8.305E-07   **NA/ND**
RHENIUM         4.428E-03   **NA/ND**   **NA/ND**   ***  ***  **NA/ND**   **NA/ND**   **NA/ND**   **NA/ND**
OSMIUM          2.084E-03   **NA/ND**   **NA/ND**   ***  ***  **NA/ND**   **NA/ND**   **NA/ND**   **NA/ND**
IRIDIUM         1.910E-03   **NA/ND**   **NA/ND**   ***  ***  **NA/ND**   **NA/ND**   **NA/ND**   **NA/ND**
GOLD            1.302E-03   **NA/ND**   **NA/ND**   ***  ***  **NA/ND**   **NA/ND**   **NA/ND**   **NA/ND**
THALLIUM        1.215E+00   1.000E+02   **NA/ND**   NO   ***  1.215E-02   **NA/ND**   2.836E-03   **NA/ND**
LEAD            1.910E-03   1.500E+02   **NA/ND**   NO   ***  1.273E-05   **NA/ND**   2.971E-06   **NA/ND**
BISMUTH         1.302E-02   4.100E+02   **NA/ND**   NO   ***  3.176E-05   **NA/ND**   7.410E-06   **NA/ND**
THORIUM         2.431E-01   4.200E+02   **NA/ND**   NO   ***  5.788E-04   **NA/ND**   1.350E-04   **NA/ND**
URANIUM         6.164E-02   9.000E+00   **NA/ND**   NO   ***  6.849E-03   **NA/ND**   1.598E-03   **NA/ND**
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                                   EX1-03-01-CC 3+10   CYCL.

              N.B.  POLLUTANT CONCENTRATIONS ARE QUOTED IN PARTS PER MILLION BY WEIGHT. THESE HAVE BEEN CONVERTED
                    TO MICROGRAMS PER CUBIC METER OF FLUE GAS


                        ( **NA/ND** DENOTES DATA NOT AVAILBLE OR NOT DETERMINED )

POLLUTANT        DISCHARGE           AIR  DMEG          IF        DISCHARGE SEVERITY           WEIGHTED
 SPECIES       CONCENTRATION                           DMEG                                    DISCHARGE
                                                     EXCEEDED                                  SEVERITY
                            (HEALTH)   (ECOLOGICAL)  (H)  (E)   (HEALTH)      (ECOLOGICAL)   (HEALTH)  (ECOLOGICAL)


                          3                 3
               (MICROGRAMS/METER ) (MICROGRAMS/METER )                                        (METERS*3/SEC.)


LITHIUM          1.129E-01   2.200E+01   **NA/ND**    NO   ***   5.130E-03    **NA/ND**     1.197E-03    **NA/ND**
BERYLLIUM        1.650E-02   2.000E+00   **NA/ND**    NO   ***   8.248E-03    **NA/ND**     1.924E-03    **NA/ND**
BORON            1.042E+00   3.100E+03   **NA/ND**    NO   ***   3.361E-04    **NA/ND**     7.841E-05    **NA/ND**
FLUORINE         4.341E+00   2.500E+03   **NA/ND**    NO   ***   1.736E-03    **NA/ND**     4.051E-04    **NA/ND**
SODIUM           2.431E+00   5.300E+04   **NA/ND**    NO   ***   4.587E-05    **NA/ND**     1.070E-05    **NA/ND**
MAGNESIUM        1.215E+01   6.000E+03   **NA/ND**    NO   ***   2.026E-03    **NA/ND**     4.726E-04    **NA/ND**
ALUMINIUM        8.682E+01   5.200E+03   **NA/ND**    NO   ***   1.670E-02    **NA/ND**     3.895E-03    **NA/ND**
SILICON          8.682E+01   1.000E+04   **NA/ND**    NO   ***   8.682E-03    **NA/ND**     2.026E-03    **NA/ND**
PHOSPHORUS       1.042E+01   1.000E+02   **NA/ND**    NO   ***   1.042E-01    **NA/ND**     2.431E-02    **NA/ND**
SULPHUR          8.682E+01   **NA/ND**   **NA/ND**    ***  ***   **NA/ND**    **NA/ND**     **NA/ND**    **NA/ND**
CHLORINE         2.605E+00   **NA/ND**   **NA/ND**    ***  ***   **NA/ND**    **NA/ND**     **NA/ND**    **NA/ND**
POTASSIUM        3.126E+01   **NA/ND**   **NA/ND**    ***  ***   **NA/ND**    **NA/ND**     **NA/ND**    **NA/ND**
CALCIUM(ION)     8.682E+01   1.600E+04   **NA/ND**    NO   ***   5.426E-03    **NA/ND**     1.266E-03    **NA/ND**
TITANIUM         8.161E+01   6.000E+03   **NA/ND**    NO   ***   1.360E-02    **NA/ND**     3.173E-03    **NA/ND**
VANADIUM         2.257E+00   5.000E+02   1.000E+00    NO   YES   4.515E-03    2.257E+00     1.053E-03    5.266E-01
CHROMIUM         3.126E+00   1.000E+00   **NA/ND**    YES  ***   3.126E+00    **NA/ND**     7.292E-01    **NA/ND**
MANGANESE        1.563E+00   5.000E+03   **NA/ND**    NO   ***   3.126E-04    **NA/ND**     7.292E-05    **NA/ND**
IRON             8.682E+01   1.000E+03   **NA/ND**    NO   ***   8.682E-02    **NA/ND**     2.026E-02    **NA/ND**
COBALT           7.640E-01   5.000E+01   **NA/ND**    NO   ***   1.528E-02    **NA/ND**     3.565E-03    **NA/ND**
NICKEL           6.598E+00   1.500E+01   **NA/ND**    NO   ***   4.399E-01    **NA/ND**     1.026E-01    **NA/ND**
COPPER           8.682E-01   2.000E+02   **NA/ND**    NO   ***   4.341E-03    **NA/ND**     1.013E-03    **NA/ND**
ZINC             1.129E+00   4.000E+03   **NA/ND**    NO   ***   2.822E-04    **NA/ND**     6.583E-05    **NA/ND**
GALLIUM          2.865E-01   5.000E+03   **NA/ND**    NO   ***   5.730E-05    **NA/ND**     1.337E-05    **NA/ND**
GERMANIUM        1.650E-02   5.600E+02   **NA/ND**    NO   ***   2.946E-05    **NA/ND**     6.872E-06    **NA/ND**
ARSENIC          3.039E-01   2.000E+00   **NA/ND**    NO   ***   1.519E-01    **NA/ND**     3.545E-02    **NA/ND**
SELENIUM         9.550E-01   2.000E+02   **NA/ND**    NO   ***   4.775E-03    **NA/ND**     1.114E-03    **NA/ND**
BROMINE          2.431E-01   **NA/ND**   **NA/ND**    ***  ***   **NA/ND**    **NA/ND**     **NA/ND**    **NA/ND**
RUBIDIUM         4.862E-01   1.200E+05   **NA/ND**    NO   ***   4.052E-06    **NA/ND**     9.452E-07    **NA/ND**
STRONTIUM        1.302E+01   3.100E+03   **NA/ND**    NO   ***   4.201E-03    **NA/ND**     9.801E-04    **NA/ND**
YTTRIUM          1.997E+00   1.000E+03   **NA/ND**    NO   ***   1.997E-03    **NA/ND**     4.659E-04    **NA/ND**
ZIRCONIUM        2.691E+00   5.000E+03   **NA/ND**    NO   ***   5.383E-04    **NA/ND**     1.256E-04    **NA/ND**
NIOBIUM          2.344E-01   2.200E+04   **NA/ND**    NO   ***   1.066E-05    **NA/ND**     2.486E-06    **NA/ND**
MOLYBDENUM       2.257E-01   5.000E+03   **NA/ND**    NO   ***   4.515E-05    **NA/ND**     1.053E-05    **NA/ND**
RUTHENIUM      NOT FOUND AS INPUT
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                              SAM / 1A ANALYSIS :    INORGANIC EMISSIONS

SAM / 1A, A SOURCE ANALYSIS MODEL ,WHICH IS BASED ON A COMPARISON OF DISCHARGE CONCENTRATIONS WITH A SET OF DISCHARGE
MULTIMEDIA ENVIRONMENTAL GOALS (DMEG) CRITERIA ESTABLISHED BY THE U.S. E.P.A., IS USED FOR RAPID SCREENING OF EACH
DISCHARGE STREAM FROM FLUIDIZED BED COAL COMBUSTION PROCESS.

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                                     BACKGROUND INFORMATION

PROCESS CHARACTERISTICS    SOURCE :                        EXXON MINIPLANT WITH REGENERATION

                           BED TEMPERATURE :               894 C

                           PRESSURE :                      760  KPA

                           BED HEIGHT :                    3.10 M

                           FLUIDIZING VELOCITY :           1.46 M/C

                           COAL TYPE :                     CHAMPOIN

                           SORBENT TYPE :                  GROVE LIMESTONE


SAMPLING CHARACTERISTICS   TEST DATE :                     MAY 4 1979

                           TEST NUMBER :                   03

                           SAMPLING GROUP(S) :

                           STREAM SAMPLED :                GILUTED COMB GAS

                           SAMPLING TECHNIQUE :            SASS TRAIN


STREAM CHARACTERISTICS     STREAM ANALYZED :               EX1-03-01-CC 3+10   CYCL.

                           SAMPLE TYPE :                   PARTICULATE

                           ANALYTICAL TECHNIQUE :          SPARK SOURCE MASS SP

                           STREAM FLOW RATE :              2.333E-01     (CUBIC METER/SEC)

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POLLUTANT        DISCHARGE            AIR  DMEG                IF        DISCHARGE SEVERITY               WEIGHTED
 SPECIES       CONCENTRATION                                  DMEG                                         DISCHARGE
                                                            EXCEEDED                                       SEVERITY
                                 (HEALTH)    (ECOLOGICAL)   (H)  (E)   (HEALTH)      (ECOLOGICAL)     (HEALTH)   (ECOLOGICAL)


                                      3                 3
                (MICROGRAMS/METER ) (MICROGRAMS/METER )                                                   (METERS*3/SEC.)

RHODIUM          4.195E-03     1.000E+00     **NA/ND**      NO   ***   4.195E-03      **NA/ND**       9.788E-04      **NA/ND**
PALLADIUM        3.509E-02     **NA/ND**     **NA/ND**      ***  ***   **NA/ND**      **NA/ND**       **NA/ND**      **NA/ND**
CADMIUM          4.958E-02     1.000E+01     **NA/ND**      NO   ***   4.958E-03      **NA/ND**       1.157E-03      **NA/ND**
INDIUM           **NA/ND**     1.000E+02     **NA/ND**      ***  ***   **NA/ND**      **NA/ND**       **NA/ND**      **NA/ND**
TIN              4.577E-01     **NA/ND**     **NA/ND**      ***  ***   **NA/ND**      **NA/ND**       **NA/ND**      **NA/ND**
ANTIMONY         2.479E-01     5.000E+02     **NA/ND**      NO   ***   4.958E-04      **NA/ND**       1.157E-04      **NA/ND**
TELLURIUM        3.127E-02     1.000E+02     **NA/ND**      NO   ***   3.127E-04      **NA/ND**       7.296E-05      **NA/ND**
IODINE           3.471E-02     **NA/ND**     **NA/ND**      ***  ***   **NA/ND**      **NA/ND**       **NA/ND**      **NA/ND**
CESIUM           1.526E-01     8.200E+04     **NA/ND**      NO   ***   1.860E-06      **NA/ND**       4.341E-07      **NA/ND**
BARIUM           3.433E+01     5.000E+02     **NA/ND**      NO   ***   6.865E-02      **NA/ND**       1.602E-02      **NA/ND**
LANTHANUM        1.030E+01     1.100E+05     **NA/ND**      NO   ***   9.362E-05      **NA/ND**       2.184E-05      **NA/ND**
CERIUM           7.247E+00     3.700E+04     **NA/ND**      NO   ***   1.959E-04      **NA/ND**       4.569E-05      **NA/ND**
PRASEODYMIUM     6.484E-01     5.100E+04     **NA/ND**      NO   ***   1.271E-05      **NA/ND**       2.966E-06      **NA/ND**
NEODYMIUM        2.822E+00     **NA/ND**     **NA/ND**      ***  ***   **NA/ND**      **NA/ND**       **NA/ND**      **NA/ND**
SAMARIUM         8.772E-01     5.300E+04     **NA/ND**      NO   ***   1.655E-05      **NA/ND**       3.861E-06      **NA/ND**
EUROPIUM         8.009E-02     **NA/ND**     **NA/ND**      ***  ***   **NA/ND**      **NA/ND**       **NA/ND**      **NA/ND**
GADOLINIUM       4.577E-02     **NA/ND**     **NA/ND**      ***  ***   **NA/ND**      **NA/ND**       **NA/ND**      **NA/ND**
TERBIUM          1.487E-02     **NA/ND**     **NA/ND**      ***  ***   **NA/ND**      **NA/ND**       **NA/ND**      **NA/ND**
DYSPROSIUM       3.051E-01     9.300E+03     **NA/ND**      NO   ***   3.281E-05      **NA/ND**       7.654E-06      **NA/ND**
HOLIMIUM         3.051E-02     **NA/ND**     **NA/ND**      ***  ***   **NA/ND**      **NA/ND**       **NA/ND**      **NA/ND**
ERBIUM           4.577E-01     **NA/ND**     **NA/ND**      ***  ***   **NA/ND**      **NA/ND**       **NA/ND**      **NA/ND**
THULIUM          4.577E-02     **NA/ND**     **NA/ND**      ***  ***   **NA/ND**      **NA/ND**       **NA/ND**      **NA/ND**
YTTERBIUM        1.144E-01     1.000E+03     **NA/ND**      NO   ***   1.144E-04      **NA/ND**       2.669E-05      **NA/ND**
LUTETIUM         5.721E-02     **NA/ND**     **NA/ND**      ***  ***   **NA/ND**      **NA/ND**       **NA/ND**      **NA/ND**
HAFFNIUM         2.060E-01     5.000E+02     **NA/ND**      NO   ***   4.119E-04      **NA/ND**       9.610E-05      **NA/ND**
TUNGSTEN         2.327E-02     1.000E+03     **NA/ND**      NO   ***   2.327E-05      **NA/ND**       5.428E-06      **NA/ND**
RHENIUM          2.822E-02     **NA/ND**     **NA/ND**      ***  ***   **NA/ND**      **NA/ND**       **NA/ND**      **NA/ND**
OSMIUM           4.195E-02     **NA/ND**     **NA/ND**      ***  ***   **NA/ND**      **NA/ND**       **NA/ND**      **NA/ND**
IRIDIUM          1.754E-02     **NA/ND**     **NA/ND**      ***  ***   **NA/ND**      **NA/ND**       **NA/ND**      **NA/ND**
GOLD             1.144E-02     **NA/ND**     **NA/ND**      ***  ***   **NA/ND**      **NA/ND**       **NA/ND**      **NA/ND**
THALLIUM         6.102E+00     1.000E+02     **NA/ND**      NO   ***   6.102E-02      **NA/ND**       1.424E-02      **NA/ND**
LEAD             4.195E+00     1.500E+02     **NA/ND**      NO   ***   2.797E-02      **NA/ND**       6.525E-03      **NA/ND**
BISMUTH          8.391E-02     4.100E+02     **NA/ND**      NO   ***   2.047E-04      **NA/ND**       4.775E-05      **NA/ND**
THORIUM          1.564E+00     4.200E+02     **NA/ND**      NO   ***   3.723E-03      **NA/ND**       8.686E-04      **NA/ND**
URANIUM          1.945E-01     9.000E+00     **NA/ND**      NO   ***   2.161E-02      **NA/ND**       5.042E-03      **NA/ND**
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                                       EXI-03-01-IC 1-3   CYCL.

        N.B.  POLLUTANT CONCENTRATIONS ARE QUOTED IN PARTS PER MILLION BY WEIGHT. THESE HAVE BEEN CONVERTED
              TO MICROGRAMS PER CUBIC METER OF FLUE GAS


                              ( **NA/ND** DENOTES DATA NOT AVAILBLE OR NOT DETERMINED )

 POLLUTANT       DISCHARGE         AIR  DMEG             IF        DISCHARGE SEVERITY            WEIGHTED
  SPECIES      CONCENTRATION                            DMEG                                    DISCHARGE
                                                      EXCEEDED                                   SEVERITY
                            (HEALTH)   (ECOLOGICAL)  (H)  (E)   (HEALTH)      (ECOLOGICAL)    (HEALTH)  (ECOLOGICAL)


                         3                   3
              (MICROGRAMS/METER ) (MICROGRAMS/METER )
                                                                                              (METERS*3/SEC.)

 LITHIUM        2.136E+00   2.200E+01   **NA/ND**    NO  ***   9.708E-02    **NA/ND**     2.265E-02     **NA/ND**
 BERYLLIUM      2.937E-01   2.000E+00   **NA/ND**    NO  ***   1.468E-01    **NA/ND**     3.426E-02     **NA/ND**
 BORON          1.395E+01   3.100E+03   **NA/ND**    NO  ***   4.306E-03    **NA/ND**     1.005E-03     **NA/ND**
 FLUORINE       2.670E+01   2.500E+03   **NA/ND**    NO  ***   1.068E-02    **NA/ND**     2.491E-03     **NA/ND**
 SODIUM         4.195E+01   5.300E+04   **NA/ND**    NO  ***   7.916E-04    **NA/ND**     1.847E-04     **NA/ND**
 MAGNESIUM      7.247E+01   6.000E+03   **NA/ND**    NO  ***   1.208E-02    **NA/ND**     2.818E-03     **NA/ND**
 ALUMINIUM      1.259E+02   5.200E+03   **NA/ND**    NO  ***   2.420E-02    **NA/ND**     5.647E-03     **NA/ND**
 SILICON        3.814E+02   1.000E+04   **NA/ND**    NO  ***   3.814E-02    **NA/ND**     8.898E-03     **NA/ND**
 PHOSPHORUS     9.154E+01   1.000E+02   **NA/ND**    NO  ***   9.154E-01    **NA/ND**     2.136E-01     **NA/ND**
 SULPHUR        3.814E+02   **NA/ND**   **NA/ND**   ***  ***   **NA/ND**    **NA/ND**     **NA/ND**     **NA/ND**
 CHLORINE       1.678E+01   **NA/ND**   **NA/ND**   ***  ***   **NA/ND**    **NA/ND**     **NA/ND**     **NA/ND**
 POTASSIUM      1.983E+02   **NA/ND**   **NA/ND**   ***  ***   **NA/ND**    **NA/ND**     **NA/ND**     **NA/ND**
 CALCIUM(ION)   3.814E+02   1.600E+04   **NA/ND**    NO  ***   2.384E-02    **NA/ND**     5.561F-03     **NA/ND**
 TITANIUM       2.517E+02   6.000E+03   **NA/ND**    NO  ***   4.195E-02    **NA/ND**     9.788E-03     **NA/ND**
 VANADIUM       2.021E+01   5.000E+02   1.000E+00    NO  YES   4.043E-02    2.021E+01     9.432E-03     4.716E+00
 CHROMIUM       9.916E+00   1.000E+00   **NA/ND**   YES  ***   9.916E+00    **NA/ND**     2.313E+00     **NA/ND**
 MANGANESE      4.958E+00   5.000E+03   **NA/ND**    NO  ***   9.916E-04    **NA/ND**     2.313E-04     **NA/ND**
 IRON           3.814E+02   1.000E+03   **NA/ND**    NO  ***   3.814E-01    **NA/ND**     8.898E-02     **NA/ND**
 COBALT         1.716E+00   5.000E+01   **NA/ND**    NO  ***   3.433E-02    **NA/ND**     8.008E-03     **NA/ND**
 NICKEL         2.098E+01   1.500E+01   **NA/ND**   YES  ***   1.398E+00    **NA/ND**     3.263E-01     **NA/ND**
 COPPER         2.670E+00   2.000E+02   **NA/ND**    NO  ***   1.335E-02    **NA/ND**     3.114E-03     **NA/ND**
 ZINC           4.195E+00   4.000E+03   **NA/ND**    NO  ***   1.049E-03    **NA/ND**     2.447E-04     **NA/ND**
 GALLIUM        1.678E+00   5.000E+03   **NA/ND**    NO  ***   3.356E-04    **NA/ND**     7.830E-05     **NA/ND**
 GERMANIUM      5.721E-01   5.600E+02   **NA/ND**    NO  ***   1.022E-03    **NA/ND**     2.383E-04     **NA/ND**
 ARSENIC        2.746E+00   2.000E+00   **NA/ND**   YES  ***   1.373E+00    **NA/ND**     3.203E-01     **NA/ND**
 SELENIUM       3.013E+00   2.000E+02   **NA/ND**    NO  ***   1.507E-02    **NA/ND**     3.515E-03     **NA/ND**
 BROMINE        1.640E+00   **NA/ND**   **NA/ND**   ***  ***   **NA/ND**    **NA/ND**     **NA/ND**     **NA/ND**
 RUBIDIUM       3.089E+00   1.200E+05   **NA/ND**    NO  ***   2.574E-05    **NA/ND**     6.006E-06     **NA/ND**
 STRONTIUM      8.391E+01   3.100E+03   **NA/ND**    NO  ***   2.707E-02    **NA/ND**     6.315E-03     **NA/ND**
 YTTRIUM        8.772E+00   1.000E+03   **NA/ND**    NO  ***   8.772E-03    **NA/ND**     2.047E-03     **NA/ND**
 ZIRCONIUM      2.174E+01   5.000E+03   **NA/ND**    NO  ***   4.348E-03    **NA/ND**     1.014E-03     **NA/ND**
 NIOBIUM        2.098E+00   2.200E+04   **NA/ND**    NO  ***   9.535E-05    **NA/ND**     2.225E-05     **NA/ND**
 MOLYBDENUM     3.547E-01   5.000E+03   **NA/ND**    NO  ***   7.094E-05    **NA/ND**     1.655E-05     **NA/ND**
 RUTHENIUM      2.708E-02   **NA/ND**   **NA/ND**   ***  ***   **NA/ND**    **NA/ND**     **NA/ND**     **NA/ND**
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                             SAM / IA ANALYSIS :    INORGANIC EMISSIONS

SAM / IA, A SOURCE ANALYSIS MODEL ,WHICH IS BASED ON A COMPARISON OF DISCHARGE CONCENTRATIONS WITH A SET OF DISCHARGE
MULTIMEDIA ENVIRONMENTAL GOALS (DMEG) CRITERIA ESTABLISHED BY THE U.S. E.P.A., IS USED FOR RAPID SCREENING OF EACH
DISCHARGE STREAM FROM FLUIDIZED BED COAL COMBUSTION PROCESS.

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                                      BACKGROUND INFORMATION

PROCESS CHARACTERISTICS     SOURCE :                        EXXON MINIPLANT WITH REGENERATION

                            BED TEMPERATURE :               894 C

           .                PRESSURE :                      760  KPA

                            BED HEIGHT :                    3.10 M

                            FLUIDIZING VELOCITY :           1.46 MS

                            COAL TYPE :                     CHAMPUIN

                            SORBENT TYPE :                  GROVE LIMESTONE


SAMPLING CHARACTERISTICS    TEST DATE :                     MAY 4 1979

                            TEST NUMBER :                   03

                            SAMPLING GROUP(S) :

                            STREAM SAMPLED :                DILUTED COMB GAS

                            SAMPLING TECHNIQUE :            SASS TRAIN


STREAM CHARACTERISTICS      STREAM ANALYZED :               EXI-03-01-1C 1-3   CYCL.

                            SAMPLE TYPE :                   PARTICULATE

                            ANALYTICAL TECHNIQUE :          SPARK SOURCE MASS SP

                            STREAM FLOW RATE :              2.333E-01     (CUBIC METER/SEC)

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                              EXI-1-05  COMB GAS TOTAL

                  SUBTOTAL INORGANIC DISCHARGE SEVERITY FROM THE EFFLUENT STREAM :


SUBTOTAL DISCHARGE SEVERITY (HEALTH DMEG BASED) =       1.318E+02
SUBTOTAL DISCHARGE SEVERITY (ECOL DMEG BASED) =        23.000E-01

                  SUBTOTAL INORGANIC WEIGHTED DISCHARGE SEVERITY FROM THE EFFLUENT STREAM :


SUBTOTAL WEIGHTED DISCHARGE SEVERITY (HEALTH DMEG BASED) =       < 3.075E+01
SUBTOTAL WEIGHTED DISCHARGE SEVERITY (ECOLOGICAL DMEG BASED) =  < 5.366E-01
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POLLUTANT          DISCHARGE         AIR  DMEG                 IF         DISCHARGE SEVERITY                  WEIGHTED
 SPECIES         CONCENTRATION                                DMEG                                           DISCHARGE
                                                            EXCEEDED                                         SEVERITY
                                  (HEALTH)   (ECOLOGICAL)   (H)  (E)   (HEALTH)      (ECOLOGICAL)      (HEALTH)   (ECOLOGICAL)


                              3                    3
               (MICROGRAMS/METER ) (MICROGRAMS/METER )                                                      (METERS*3/SEC.)

RHODIUM           2.700E+00     1.000E+00     **NA/ND**     YES  ***    2.700E+00       **NA/ND**       6.299E-01       **NA/ND**
PALLADIUM       < 1.200E+00     **NA/ND**     **NA/ND**     ***  *** < **NA/ND**     < **NA/ND**     < **NA/ND**     < **NA/ND**
CADMIUM           9.000E-01     1.000E+01     **NA/ND**     NO   ***    9.000E-02       **NA/ND**       2.100E-02       **NA/ND**
INDIUM           NOT FOUND AS INPUT
TIN               1.600E+01     **NA/ND**     **NA/ND**     ***  ***    **NA/ND**       **NA/ND**       **NA/ND**       **NA/ND**
ANTIMONY          8.000E-01     5.000E+02     **NA/ND**     NO   ***    1.600E-03       **NA/ND**       3.733E-04       **NA/ND**
TELLURIUM         2.600E+00     1.000E+02     **NA/ND**     NO   ***    2.600E-02       **NA/ND**       6.066E-03       **NA/ND**
IODINE            2.600E+00     **NA/ND**     **NA/ND**     ***  ***    **NA/ND**       **NA/ND**       **NA/ND**       **NA/ND**
CESIUM          < 1.000E-01     8.200E+04     **NA/ND**     NO   *** < 1.220E-06     < **NA/ND**     < 2.845E-07     < **NA/ND**
BARIUM            4.900E+00     5.000E+02     **NA/ND**     NO   ***    9.800E-03       **NA/ND**       2.286E-03       **NA/ND**
LANTHANUM         5.000E-01     1.100E+05     **NA/ND**     NO   ***    4.545E-06       **NA/ND**       1.060E-06       **NA/ND**
CERIUM            5.000E-01     3.700E+04     **NA/ND**     NO   ***    1.351E-05       **NA/ND**       3.153E-06       **NA/ND**
PRASEODYMIUM    < 4.000E-01     5.100E+04     **NA/ND**     NO   *** < 7.843E-06     < **NA/ND**     < 1.830E-06     < **NA/ND**
NEODYMIUM         2.100E+00     **NA/ND**     **NA/ND**     ***  ***    **NA/ND**       **NA/ND**       **NA/ND**       **NA/ND**
SAMARIUM        < 1.700E+00     5.300E+04     **NA/ND**     NO   *** < 3.208E-05     < **NA/ND**     < 7.483E-06     < **NA/ND**
EUROPIUM        < 4.000E-01     **NA/ND**     **NA/ND**     ***  *** < **NA/ND**     < **NA/ND**     < **NA/ND**     < **NA/ND**
GADOLINIUM      < 9.000E-01     **NA/ND**     **NA/ND**     ***  *** < **NA/ND**     < **NA/ND**     < **NA/ND**     < **NA/ND**
TERBIUM         < 3.000E-01     **NA/ND**     **NA/ND**     ***  *** < **NA/ND**     < **NA/ND**     < **NA/ND**     < **NA/ND**
DYSPROSIUM      < 1.000E+00     9.300E+03     **NA/ND**     NO   *** < 1.075E-04     < **NA/ND**     < 2.509E-05     < **NA/ND**
HOLIMIUM        < 5.000E-01     **NA/ND**     **NA/ND**     ***  *** < **NA/ND**     < **NA/ND**     < **NA/ND**     < **NA/ND**
ERBIUM          < 1.700E+00     **NA/ND**     **NA/ND**     ***  *** < **NA/ND**     < **NA/ND**     < **NA/ND**     < **NA/ND**
THULIUM         < 6.000E-01     **NA/ND**     **NA/ND**     ***  *** < **NA/ND**     < **NA/ND**     < **NA/ND**     < **NA/ND**
YTTERBIUM       < 9.000E-01     1.000E+03     **NA/ND**     NO   *** < 9.000E-04     < **NA/ND**     < 2.100E-04     < **NA/ND**
LUTETIUM        < 6.000E-01     **NA/ND**     **NA/ND**     ***  *** < **NA/ND**     < **NA/ND**     < **NA/ND**     < **NA/ND**
HAFFNIUM        < 2.700E+00     5.000E+02     **NA/ND**     NO   *** < 5.400E-03     < **NA/ND**     < 1.260E-03     < **NA/ND**
TUNGSTEN        < 2.200E+00     1.000E+03     **NA/ND**     NO   *** < 2.200E-03     < **NA/ND**     < 5.133E-04     < **NA/ND**
RHENIUM         < 1.600E+00     **NA/ND**     **NA/ND**     ***  *** < **NA/ND**     < **NA/ND**     < **NA/ND**     < **NA/ND**
OSMIUM          < 2.600E+00     **NA/ND**     **NA/ND**     ***  *** < **NA/ND**     < **NA/ND**     < **NA/ND**     < **NA/ND**
IRIDIUM         < 2.400E+00     **NA/ND**     **NA/ND**     ***  *** < **NA/ND**     < **NA/ND**     < **NA/ND**     < **NA/ND**
GOLD            < 1.500E+00     **NA/ND**     **NA/ND**     ***  *** < **NA/ND**     < **NA/ND**     < **NA/ND**     < **NA/ND**
THALLIUM        < 1.200E+00     1.000E+02     **NA/ND**     NO   *** < 1.200E-02     < **NA/ND**     < 2.800E-03     < **NA/ND**
LEAD              7.900E+00     1.500E+02     **NA/ND**     NO   ***    5.267E-02       **NA/ND**       1.229E-02       **NA/ND**
BISMUTH         < 9.000E-01     4.100E+02     **NA/ND**     NO   *** < 2.195E-03     < **NA/ND**     < 5.121E-04     < **NA/ND**
THORIUM         < 3.000E+00     4.200E+02     **NA/ND**     NO   *** < 7.143E-03     < **NA/ND**     < 1.666E-03     < **NA/ND**
URANIUM         < 2.100E+00     9.000E+00     **NA/ND**     NO   *** < 2.333E-01     < **NA/ND**     < 5.444E-02     < **NA/ND**
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                                   EXI-3-01  COMB GAS TOTAL

              N.B.  POLLUTANT CONCENTRATIONS ARE QUOTED IN PARTS PER MILLION BY WEIGHT. THESE HAVE BEEN CONVERTED
                    TO MICROGRAMS PER CUBIC METER OF FLUE GAS


                          ( **NA/ND** DENOTES DATA NOT AVAILABLE OR NOT DETERMINED )

 POLLUTANT       DISCHARGE           AIR  DMEG              IF        DISCHARGE SEVERITY              WEIGHTED
  SPECIES      CONCENTRATION                               DMEG                                       DISCHARGE
                                                         EXCEEDED                                     SEVERITY
                               (HEALTH)    (ECOLOGICAL)  (H)  (E)   (HEALTH)        (ECOLOGICAL)    (HEALTH)   (ECOLOGICAL)


                                   3                 3
               (MICROGRAMS/METER ) (MICROGRAMS/METER )                                             (METERS*3/SEC.)


 LITHIUM        1.000E-01     2.200E+01    **NA/ND**     NO   ***   4.545E-03      **NA/ND**       1.060E-03     **NA/ND**
 BERYLLIUM      5.000E-01     2.000E+00    **NA/ND**     NO   ***   1.500E-01      **NA/ND**       3.499E-02     **NA/ND**
 BORON          7.000E+00     3.100E+03    **NA/ND**     NO   ***   2.258E-03      **NA/ND**       5.268E-04     **NA/ND**
 FLUORINE       5.100E+01     2.500E+03    **NA/ND**     NO   ***   1.240E-02      **NA/ND**       2.893E-03     **NA/ND**
 SODIUM         3.000E+01     5.300E+04    **NA/ND**     NO   ***   5.660E-04      **NA/ND**       1.321E-04     **NA/ND**
 MAGNESIUM      5.200E+01     6.000E+03    **NA/ND**     NO   ***   8.667E-03      **NA/ND**       2.022E-03     **NA/ND**
 ALUMINIUM      2.100E+02     5.200E+03    **NA/ND**     NO   ***   4.038E-02      **NA/ND**       9.422E-03     **NA/ND**
 SILICON        1.000E+02     1.000E+04    **NA/ND**     NO   ***   1.000E-02      **NA/ND**       2.333E-03     **NA/ND**
 PHOSPHORUS     2.200E+01     1.000E+02    **NA/ND**     NO   ***   2.200E-01      **NA/ND**       5.133E-02     **NA/ND**
 SULPHUR        1.578E+06     **NA/ND**    **NA/ND**     ***  ***   **NA/ND**      **NA/ND**       **NA/ND**     **NA/ND**
 CHLORINE      NOT FOUND AS INPUT
 POTASSIUM      4.600E+01     **NA/ND**    **NA/ND**     ***  ***   **NA/ND**      **NA/ND**       **NA/ND**     **NA/ND**
 CALCIUM(ION)   3.600E+02     1.600E+04    **NA/ND**     NO   ***   2.250E-02      **NA/ND**       5.249E-03     **NA/ND**
 TITANIUM       6.400E+00     6.000E+03    **NA/ND**     NO   ***   1.067E-03      **NA/ND**       2.489E-04     **NA/ND**
 VANADIUM       2.300E+00     5.000E+02    1.000E+00     NO   YES   4.600E-03      2.300E+00       1.073E-03     5.366E-01
 CHROMIUM       1.100E+02     1.000E+00    **NA/ND**     YES  ***   1.100E+02      **NA/ND**       2.566E+01     **NA/ND**
 MANGANESE      1.600E+01     5.000E+03    **NA/ND**     NO   ***   3.200E-03      **NA/ND**       7.466E-04     **NA/ND**
 IRON           8.500E+02     1.000E+03    **NA/ND**     NO   ***   8.500E-01      **NA/ND**       1.983E-01     **NA/ND**
 COBALT         7.100E+00     5.000E+01    **NA/ND**     NO   ***   1.420E-01      **NA/ND**       3.313E-02     **NA/ND**
 NICKEL         2.400E+02     1.500E+01    **NA/ND**     YES  ***   1.600E+01      **NA/ND**       3.733E+00     **NA/ND**
 COPPER         6.900E+01     2.000E+02    **NA/ND**     NO   ***   3.450E-01      **NA/ND**       8.049E-02     **NA/ND**
 ZINC           2.700E+01     4.000E+03    **NA/ND**     NO   ***   6.750E-03      **NA/ND**       1.575E-03     **NA/ND**
 GALLIUM        1.000E-01     5.000E+03    **NA/ND**     NO   ***   2.000E-05      **NA/ND**       4.666E-06     **NA/ND**
 GERMANIUM      3.000E-01     5.600E+02    **NA/ND**     NO   ***   5.357E-04      **NA/ND**       1.250E-04     **NA/ND**
 ARSENIC        1.600E+00     2.000E+00    **NA/ND**     NO   ***   8.000E-01      **NA/ND**       1.866E-01     **NA/ND**
 SELENIUM       9.900E+00     2.000E+02    **NA/ND**     NO   ***   4.950E-02      **NA/ND**       1.155E-02     **NA/ND**
 BROMINE        4.000E+00     **NA/ND**    **NA/ND**     ***  ***   **NA/ND**      **NA/ND**       **NA/ND**     **NA/ND**
 RUBIDIUM       2.000E-01     1.200E+05    **NA/ND**     NO   ***   1.667E-06      **NA/ND**       3.888E-07     **NA/ND**
 STRONTIUM      2.000E+00     3.100E+03    **NA/ND**     NO   ***   6.452E-04      **NA/ND**       1.505E-04     **NA/ND**
 YTTRIUM        2.000E-01     1.000E+03    **NA/ND**     NO   ***   2.000E-04      **NA/ND**       4.666E-05     **NA/ND**
 ZIRCONIUM      1.900E+00     5.000E+03    **NA/ND**     NO   ***   3.800E-04      **NA/ND**       8.865E-05     **NA/ND**
 NIOBIUM        5.000E-01     2.200E+04    **NA/ND**     NO   ***   2.273E-05      **NA/ND**       5.302E-06     **NA/ND**
 MOLYBDENUM     2.500E+01     5.000E+03    **NA/ND**     NO   ***   5.000E-03      **NA/ND**       1.166E-03     **NA/ND**
 RUTHENIUM      1.200E+00     **NA/ND**    **NA/ND**     ***  ***   **NA/ND**      **NA/ND**       **NA/ND**     **NA/ND**
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                              SAM / IA ANALYSIS :    INORGANIC EMISSIONS

    SAM / IA, A SOURCE ANALYSIS MODEL ,WHICH IS BASED ON A COMPARISON OF DISCHARGE CONCENTRATIONS WITH A SET OF DISCHARGE
    MULTIMEDIA ENVIRONMENTAL GOALS (DMEG) CRITERIA ESTABLISHED BY THE U.S. E.P.A., IS USED FOR RAPID SCREENING OF EACH
    DISCHARGE STREAM FROM FLUIDIZED BED COAL COMBUSTION PROCESS.

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                                               BACKGROUND INFORMATION

    PROCESS CHARACTERISTICS      SOURCE :                        EXXON MINIPLANT WITH REGENERATION

                                 BED TEMPERATURE :               894 C

                                 PRESSURE :                      760 KPA

                                 BED HEIGHT :                    3.10 M

                                 FLUIDIZING VELOCITY :           1.46 M/S

                                 COAL TYPE :                     CHAMPION

                                 SORBENT TYPE :                  GROVE LIMESTONE


    SAMPLING CHARACTERISTICS     TEST DATE :                     MAY 4 1979

                                 TEST NUMBER :

                                 SAMPLING GROUP(S) :

                                 STREAM SAMPLED :                COMB FLUE GAS

                                 SAMPLING TECHNIQUE :            SASS TRAIN


    STREAM CHARACTERISTICS       STREAM ANALYZED :               EX1-3-01  COMB GAS TOTAL

                                 SAMPLE TYPE :                   PARTICULATE

                                 ANALYTICAL TECHNIQUE :          SPARK SOURCE MASS SP

                                 STREAM FLOW RATE :              2.333E-01     (CUBIC METER/SEC)

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                          SAM / 1A ANALYSIS :    INORGANIC EMISSIONS

SAM / 1A, A SOURCE ANALYSIS MODEL ,WHICH IS BASED ON A COMPARISON OF DISCHARGE CONCENTRATIONS WITH A SET OF DISCHARGE
MULTIMEDIA ENVIRONMENTAL GOALS (DMEG) CRITERIA ESTABLISHED BY THE U.S. E.P.A., IS USED FOR RAPID SCREENING OF EACH
DISCHARGE STREAM FROM FLUIDIZED BED COAL COMBUSTION PROCESS.

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                                      BACKGROUND INFORMATION

PROCESS CHARACTERISTICS      SOURCE :                         EXXON MINIPLANT WITH REGENERATION

                             BED TEMPERATURE :                894 C

                             PRESSURE :                       760  KPA

                             BED HEIGHT :                     3.10 M

                             FLUIDIZING VELOCITY :            1.46 MS

                             COAL TYPE :                      CHAMPOIN

                             SORBENT TYPE :                   GROVE LIMESTONE


SAMPLING CHARACTERISTICS     TEST DATE :                      MAY 4 1979

                             TEST NUMBER :                    03

                             SAMPLING GROUP(S) :

                             STREAM SAMPLED :                 DILUTED COMB GAS

                             SAMPLING TECHNIQUE :             MOBILE ELECTROSTATIC


STREAM CHARACTERISTICS       STREAM ANALYZED :                EX1-03-01-FA  ESP HOPPER

                             SAMPLE TYPE :                    PARTICULATE

                             ANALYTICAL TECHNIQUE :           SPARK SOURCE MASS SP

                             STREAM FLOW RATE :               2.333E-02     (   GRAMS / SEC. )

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EXI-03-01-FA ESP HOPPER

N.B. POLLUTANT CONCENTRATIONS ARE QUOTED IN PARTS PER MILLION BY WEIGHT.
THESE ARE EQUIVALENT TO MICROGRAMS/GRAM PARTICULATES.

(**NA/ND** DENOTES DATA NOT AVAILBLE OR NOT DETERMINED)

POLLUTANT SPECIES	DISCHARGE CONCENTRATION	LAND DMEG		IF DMEG EXCEEDED		DISCHARGE SEVERITY		WEIGHTED DISCHARGE SEVERITY	
		(HEALTH)	(ECOLOGICAL)	(H)	(E)	(HEALTH)	(ECOLOGICAL)	(HEALTH)	(ECOLOGICAL)
	(MICROGRAMS/GRAM)	(MICROGRAMS/GRAM)						(GRAMS/SEC.)	
LITHIUM	2.800E+01	7.000E+01	7.500E+01	NO	NO	4.000E-01	3.733E-01	9.332E-03	8.710E-03
BERYLLIUM	5.700E+00	6.000E+00	1.100E+01	NO	NO	6.167E-01	3.364E-01	1.439E-02	7.847E-03
BORON	2.400E+02	9.300E+03	5.000E+03	NO	NO	2.581E-02	4.800E-02	6.021E-04	1.120E-03
FLUORINE	1.300E+03	7.500E+03	**NA/ND**	NO	***	1.733E-01	**NA/ND**	4.044E-03	**NA/ND**
SODIUM	7.700E+02	1.600E+05	**NA/ND**	NO	***	4.812E-03	**NA/ND**	1.123E-04	**NA/ND**
MAGNESIUM	1.900E+03	1.800E+04	1.700E+04	NO	NO	1.056E-01	1.118E-01	2.463E-03	2.607E-03
ALUMINIUM	6.500E+03	1.600E+04	2.000E+02	NO	YES	4.063E-01	3.250E+01	9.478E-03	7.582E-01
SILICON	1.000E+04	3.000E+04	**NA/ND**	NO	***	3.333E-01	**NA/ND**	7.777E-03	**NA/ND**
PHOSPHORUS	1.700E+03	3.000E+03	1.000E-01	NO	YES	5.667E-01	1.700E+04	1.322E-02	3.966E+02
SULPHUR	1.000E+04	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
CHLORINE	6.100E+02	2.600E+05	**NA/ND**	NO	***	2.346E-03	**NA/ND**	5.474E-05	**NA/ND**
POTASSIUM	3.600E+03	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
CALCIUM(ION)	1.000E+04	4.800E+04	3.200E+03	NO	YES	2.083E-01	3.125E+00	4.860E-03	7.291E-02
TITANIUM	5.900E+03	1.800E+04	1.600E+02	NO	YES	3.278E-01	3.688E+01	7.647E-03	8.603E-01
VANADIUM	1.300E+02	5.000E+02	3.000E+01	NO	YES	2.600E-01	4.333E+00	6.066E-03	1.011E-01
CHROMIUM	2.600E+02	5.000E+01	5.000E+01	YES	YES	5.200E+00	5.200E+00	1.213E-01	1.213E-01
MANGANESE	1.300E+02	5.000E+01	2.000E+01	YES	YES	2.600E+00	6.500E+00	6.066E-02	1.516E-01
IRON	1.000E+04	3.000E+02	5.000E+01	YES	YES	3.333E+01	2.000E+02	7.777E-01	4.666E+00
COBALT	4.400E+01	1.500E+02	5.000E+01	NO	NO	2.933E-01	8.800E-01	6.843E-03	2.053E-02
NICKEL	5.400E+02	4.500E+01	2.000E+00	YES	YES	1.200E+01	2.700E+02	2.800E-01	6.299E+00
COPPER	1.400E+02	1.000E+03	1.000E+01	NO	YES	1.400E-01	1.400E+01	3.266E-03	3.266E-01
ZINC	3.600E+02	5.000E+03	2.000E+01	NO	YES	7.200E-02	1.800E+01	1.680E-03	4.199E-01
GALLIUM	4.700E+01	1.500E+04	**NA/ND**	NO	***	3.133E-03	**NA/ND**	7.310E-05	**NA/ND**
GERMANIUM	2.500E+01	1.700E+03	**NA/ND**	NO	***	1.471E-02	**NA/ND**	3.431E-04	**NA/ND**
ARSENIC	9.900E+01	5.000E+01	1.000E+01	YES	YES	1.980E+00	9.900E+00	4.619E-02	2.310E-01
SELENIUM	1.100E+02	1.000E+01	5.000E+00	YES	YES	1.100E+01	2.200E+01	2.566E-01	5.133E-01
BROMINE	5.900E+01	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
RUBIDIUM	5.600E+01	3.600E+05	**NA/ND**	NO	***	1.556E-04	**NA/ND**	3.629E-06	**NA/ND**
STRONTIUM	1.500E+03	9.200E+03	**NA/ND**	NO	***	1.630E-01	**NA/ND**	3.804E-03	**NA/ND**
YTTRIUM	1.600E+02	3.000E+03	**NA/ND**	NO	***	5.333E-02	**NA/ND**	1.244E-03	**NA/ND**
ZIRCONIUM	2.200E+02	1.500E+03	**NA/ND**	NO	***	1.467E-01	**NA/ND**	3.422E-03	**NA/ND**
NIOBIUM	2.700E+01	6.500E+04	**NA/ND**	NO	***	4.154E-04	**NA/ND**	9.691E-06	**NA/ND**
MOLYBDENUM	1.600E+01	1.500E+04	1.400E+03	NO	NO	1.067E-03	1.143E-02	2.489E-05	2.666E-04
RUTHENIUM	1.700E-01	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**

POLLUTANT SPECIES	DISCHARGE CONCENTRATION	LAND DMEG		IF DMEG EXCEEDED		DISCHARGE SEVERITY		WEIGHTED DISCHARGE SEVERITY	
		(HEALTH)	(ECOLOGICAL)	(H)	(E)	(HEALTH)	(ECOLOGICAL)	(HEALTH)	(ECOLOGICAL)
	(MICROGRAMS/GRAM)	(MICROGRAMS/GRAM)						(GRAMS/SEC.)	
RHODIUM	5.600E-02	3.000E+00	**NA/ND**	NO	***	1.867E-02	**NA/ND**	4.355E-04	**NA/ND**
PALLADIUM	1.300E+00	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
CADMIUM	9.500E-01	1.000E+01	2.000E-01	NO	YES	9.500E-02	4.750E+00	2.216E-03	1.108E-01
INDIUM	**NA/ND**	5.000E+00	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
TIN	7.700E+00	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
ANTIMONY	9.600E+00	1.500E+03	4.000E+01	NO	NO	6.400E-03	2.400E-01	1.493E-04	5.599E-03
TELLURIUM	1.100E+00	3.000E+02	**NA/ND**	NO	***	3.667E-03	**NA/ND**	8.554E-05	**NA/ND**
IODINE	1.300E+00	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
CESIUM	2.800E+00	2.500E+05	**NA/ND**	NO	***	1.120E-05	**NA/ND**	2.613E-07	**NA/ND**
BARIUM	7.900E+02	1.000E+03	5.000E+02	NO	YES	7.900E-01	1.580E+00	1.843E-02	3.686E-02
LANTHANUM	8.900E+01	3.400E+05	**NA/ND**	NO	***	2.618E-04	**NA/ND**	6.107E-06	**NA/ND**
CERIUM	9.400E+01	1.100E+05	**NA/ND**	NO	***	8.545E-04	**NA/ND**	1.994E-05	**NA/ND**
PRASEODYMIUM	1.200E+01	1.500E+05	**NA/ND**	NO	***	8.000E-05	**NA/ND**	1.866E-06	**NA/ND**
NEODYMIUM	3.600E+01	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
SAMARIUM	9.600E+00	1.600E+05	**NA/ND**	NO	***	6.000E-05	**NA/ND**	1.400E-06	**NA/ND**
EUROPIUM	1.400E+00	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
GADOLINIUM	7.300E-01	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
TERBIUM	3.700E-01	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
DYSPROSIUM	3.000E+00	4.600E+04	**NA/ND**	NO	***	6.522E-05	**NA/ND**	1.522E-06	**NA/ND**
HOLIMIUM	7.800E-01	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
ERBIUM	4.200E+00	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
THULIUM	6.100E-01	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
YTTERBIUM	2.000E+00	3.000E+03	**NA/ND**	NO	***	6.667E-04	**NA/ND**	1.555E-05	**NA/ND**
LUTETIUM	1.400E+00	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
HAFNIUM	3.700E+00	1.500E+02	**NA/ND**	NO	***	2.467E-02	**NA/ND**	5.755E-04	**NA/ND**
TUNGSTEN	2.900E-01	3.000E+03	**NA/ND**	NO	***	9.667E-05	**NA/ND**	2.255E-06	**NA/ND**
RHENIUM	1.500E+00	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
OSMIUM	3.500E-01	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
IRIDIUM	3.200E-01	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
GOLD	2.100E-01	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
THALLIUM	1.700E-01	3.000E+02	**NA/ND**	NO	***	5.667E-04	**NA/ND**	1.322E-05	**NA/ND**
LEAD	1.500E+02	5.000E+01	1.000E+01	YES	YES	3.000E+00	1.500E+01	6.999E-02	3.499E-01
BISMUTH	3.000E+00	1.200E+03	**NA/ND**	NO	***	2.500E-03	**NA/ND**	5.832E-05	**NA/ND**
THORIUM	1.400E+01	1.300E+02	**NA/ND**	NO	***	1.077E-01	**NA/ND**	2.512E-03	**NA/ND**
URANIUM	7.100E+00	1.200E+04	1.000E+02	NO	NO	5.917E-04	7.100E-02	1.380E-05	1.656E-03

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                         EX1-03-01-FA  ESP HOPPER

            SUBTOTAL INORGANIC DISCHARGE SEVERITY FROM THE EFFLUENT STREAM :


SUBTOTAL DISCHARGE SEVERITY (HEALTH DMEG BASED) =      7.448E+01
                             Ecological
SUBTOTAL DISCHARGE SEVERITY (HEALTH DMEG BASED) =      1.765E+04

            SUBTOTAL INORGANIC WEIGHTED DISCHARGE SEVERITY FROM THE EFFLUENT STREAM :


SUBTOTAL WEIGHTED DISCHARGE SEVERITY (HEALTH DMEG BASED) =        1.738E+00
SUBTOTAL WEIGHTED DISCHARGE SEVERITY (ECOLOGICAL DMEG BASED) =    4.117E+02
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                                  SAM / IA ANALYSIS :    INORGANIC EMISSIONS        ,

    SAM / IA, A SOURCE ANALYSIS MODEL ,WHICH IS BASED ON A COMPARISON OF DISCHARGE CONCENTRATIONS WITH A SET OF DISCHARGE
    MULTIMEDIA ENVIRONMENTAL GOALS (DMEG) CRITERIA ESTABLISHED BY THE U.S. E.P.A., IS USED FOR RAPID SCREENING OF EACH
    DISCHARGE STREAM FROM FLUIDIZED BED COAL COMBUSTION PROCESS.

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                                          BACKGROUND INFORMATION

    PROCESS CHARACTERISTICS      SOURCE :                          EXXON MINIPLANT WITH REGENERATION

                                 BED TEMPERATURE :                 894 C

                                 PRESSURE :                        760  KPA

                                 BED HEIGHT :                      5.10 M

                                 FLUIDIZING VELOCITY :             1.46 M/S

                                 COAL TYPE :                       CHAMPION

                                 SORBENT TYPE :                    GROVE LIMESTONE


    SAMPLING CHARACTERISTICS     TEST DATE :                       MAY 2 1979

                                 TEST NUMBER :                     01

                                 SAMPLING GROUP(S) :

                                 STREAM SAMPLED :                  REGENERATOR CYCLONE

                                 SAMPLING TECHNIQUE :              EX1-01-05-FAR REGEN


    STREAM CHARACTERISTICS       STREAM ANALYZED :                 LI

                                 SAMPLE TYPE :                         26.

                                 ANALYTICAL TECHNIQUE :

                                 STREAM FLOW RATE :                0.0          (   GRAMS / SEC. )

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                                  LI

          N.B.  POLLUTANT CONCENTRATIONS ARE QUOTED IN PARTS PER MILLION BY WEIGHT.
                THESE ARE EQUIVALENT TO MICROGRAMS/GRAM PARTICULATES.


                    ( **NA/ND** DENOTES DATA NOT AVAILBLE OR NOT DETERMINED )

POLLUTANT       DISCHARGE          LAND DMEG             IF      DISCHARGE SEVERITY           WEIGHTED
SPECIES       CONCENTRATION                             DMEG                                  DISCHARGE
                                                      EXCEEDED                                SEVERITY
                              (HEALTH)   (ECOLOGICAL)  (H) (E)  (HEALTH)   (ECOLOGICAL)  (HEALTH)  (ECOLOGICAL)


                                                                                          (GRAMS/SEC.)
             (MICROGRAMS/GRAM)   (MICROGRAMS/GRAM)


LITHIUM        NOT FOUND AS INPUT
BERYLLIUM       7.050E+06   6.000E+00   1.100E+01   YES YES  1.175E+06   6.409E+05   0.0         0.0
BORON           2.700E+03   9.500E+03   5.000E+03   NO   NO  2.903E-01   5.400E-01   0.0         0.0
FLUORINE        1.000E+03   7.500E+03   **NA/ND**   NO  ***  1.333E-01   **NA/ND**   0.0         **NA/ND**
SODIUM          4.000E+02   1.600E+05   **NA/ND**   NO  ***  2.500E-03   **NA/ND**   0.0         **NA/ND**
MAGNESIUM       5.700E+03   1.800E+04   1.700E+04   NO   NO  3.167E-01   3.353E-01   0.0         0.0
ALUMINIUM       6.500E+03   1.600E+04   2.000E+02   NO  YES  4.063E-01   3.250E+01   0.0         0.0
SILICON         1.000E+04   3.000E+04   **NA/ND**   NO  ***  3.333E-01   **NA/ND**   0.0         **NA/ND**
PHOSPHORUS      8.000E+02   3.000E+03   1.000E-01   NO  YES  2.667E-01   8.000E+03   0.0         0.0
SULPHUR         2.120E+04   **NA/ND**   **NA/ND**   *** ***  **NA/ND**   **NA/ND**   **NA/ND**   **NA/ND**
CHLORINE        3.400E+03   2.600E+05   **NA/ND**   NO  ***  1.308E-02   **NA/ND**   0.0         **NA/ND**
POTASSIUM       2.400E+03   **NA/ND**   **NA/ND**   *** ***  **NA/ND**   **NA/ND**   **NA/ND**   **NA/ND**
CALCIUM(ION)    3.390E+05   4.800E+04   3.200E+03   YES YES  7.063E+00   1.059E+02   0.0         0.0
TITANIUM        2.900E+03   1.800E+04   1.600E+02   NO  YES  1.611E-01   1.813E+01   0.0         0.0
VANADIUM        2.600E+02   5.000E+02   3.000E+01   NO  YES  5.200E-01   8.667E+00   0.0         0.0
CHROMIUM        6.200E+01   5.000E+01   5.000E+01   YES YES  1.240E+00   1.240E+00   0.0         0.0
MANGANESE       1.800E+02   5.000E+01   2.000E+01   YES YES  3.600E+00   9.000E+00   0.0         0.0
IRON            1.000E+04   3.000E+02   5.000E+01   YES YES  3.333E+01   2.000E+02   0.0         0.0
COBALT          4.300E+01   1.500E+02   5.000E+01   NO   NO  2.867E-01   8.600E-01   0.0         0.0
NICKEL          1.300E+02   4.500E+01   2.000E+00   YES YES  2.889E+00   6.500E+01   0.0         0.0
COPPER          4.900E+01   1.000E+03   1.000E+01   NO  YES  4.900E-02   4.900E+00   0.0         0.0
ZINC            1.600E+02   5.000E+03   2.000E+01   NO  YES  3.200E-02   8.000E+00   0.0         0.0
GALLIUM         3.200E+01   1.500E+04   **NA/ND**   NO  ***  2.133E-03   **NA/ND**   0.0         **NA/ND**
GERMANIUM       2.900E+01   1.700E+03   **NA/ND**   NO  ***  1.706E-02   **NA/ND**   0.0         **NA/ND**
ARSENIC         5.600E+02   5.000E+01   1.000E+01   YES YES  1.120E+01   5.600E+01   0.0         0.0
SELENIUM        3.100E-01   1.000E+01   5.000E+00   NO   NO  3.100E-02   6.200E-02   0.0         0.0
BROMINE         4.000E+00   **NA/ND**   **NA/ND**   *** ***  **NA/ND**   **NA/ND**   **NA/ND**   **NA/ND**
RUBIDIUM        1.900E+01   3.600E+05   **NA/ND**   NO  ***  5.278E-05   **NA/ND**   0.0         **NA/ND**
STRONTIUM       1.100E+03   9.200E+03   **NA/ND**   NO  ***  1.196E-01   **NA/ND**   0.0         **NA/ND**
YTTRIUM         5.500E+01   3.000E+03   **NA/ND**   NO  ***  1.833E-02   **NA/ND**   0.0         **NA/ND**
ZIRCONIUM       1.900E+02   1.500E+03   **NA/ND**   NO  ***  1.267E-01   **NA/ND**   0.0         **NA/ND**
NIOBIUM         2.000E+01   6.500E+04   **NA/ND**   NO  ***  3.077E-04   **NA/ND**   0.0         **NA/ND**
MOLYBDENUM      9.100E+00   1.500E+04   1.400E+03   NO   NO  6.067E-04   6.500E-03   0.0         0.0
RUTHENIUM       4.900E-01   **NA/ND**   **NA/ND**   *** ***  **NA/ND**   **NA/ND**   **NA/ND**   **NA/ND**
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POLLUTANT        DISCHARGE          LAND DMEG                IF        DISCHARGE SEVERITY              WEIGHTED
 SPECIES       CONCENTRATION                                DMEG                                      DISCHARGE
                                                          EXCEEDED                                    SEVERITY
                             (HEALTH)   (ECOLOGICAL)   (H)   (E)   (HEALTH)      (ECOLOGICAL)     (HEALTH)   (ECOLOGICAL)


              (MICROGRAMS/GRAM)   (MICROGRAMS/GRAM)                                                    (GRAMS/SEC.)

RHODIUM          1.600E-01   3.000E+00   **NA/ND**     NO    ***   5.333E-02   **NA/ND**     0.0           **NA/ND**
PALLADIUM        8.600E-01   **NA/ND**   **NA/ND**     ***   ***   **NA/ND**   **NA/ND**     **NA/ND**     **NA/ND**
CADMIUM          8.400E-01   1.000E+01   2.000E-01     NO    YES   8.400E-02   4.200E+00     0.0           0.0
INDIUM           **NA/ND**   3.000E+00   **NA/ND**     ***   ***   **NA/ND**   **NA/ND**     **NA/ND**     **NA/ND**
TIN              6.400E+00   **NA/ND**   **NA/ND**     ***   ***   **NA/ND**   **NA/ND**     **NA/ND**     **NA/ND**
ANTIMONY         3.500E+00   1.500E+03   4.000E+01     NO     NO   2.333E-03   8.750E-02     0.0           0.0
TELLURIUM        4.400E-01   3.000E+02   **NA/ND**     NO    ***   1.467E-03   **NA/ND**     0.0           **NA/ND**
IODINE           1.200E-01   **NA/ND**   **NA/ND**     ***   ***   **NA/ND**   **NA/ND**     **NA/ND**     **NA/ND**
CESIUM           9.900E-01   2.500E+05   **NA/ND**     NO    ***   3.960E-06   **NA/ND**     0.0           **NA/ND**
BARIUM           2.800E+02   1.000E+03   5.000E+02     NO     NO   2.800E-01   5.600E-01     0.0           0.0
LANTHANUM        4.600E+01   3.400E+05   **NA/ND**     NO    ***   1.353E-04   **NA/ND**     0.0           **NA/ND**
CERIUM           4.500E+01   1.100E+05   **NA/ND**     NO    ***   4.091E-04   **NA/ND**     0.0           **NA/ND**
PRASEODYMIUM     4.200E+00   1.500E+05   **NA/ND**     NO    ***   2.800E-05   **NA/ND**     0.0           **NA/ND**
NEODYMIUM        1.400E+01   **NA/ND**   **NA/ND**     ***   ***   **NA/ND**   **NA/ND**     **NA/ND**     **NA/ND**
SAMARIUM         2.900E+00   1.600E+05   **NA/ND**     NO    ***   1.812E-05   **NA/ND**     0.0           **NA/ND**
EUROPIUM         3.600E-01   **NA/ND**   **NA/ND**     ***   ***   **NA/ND**   **NA/ND**     **NA/ND**     **NA/ND**
GADOLINIUM       5.700E-01   **NA/ND**   **NA/ND**     ***   ***   **NA/ND**   **NA/ND**     **NA/ND**     **NA/ND**
TERBIUM          1.400E-01   **NA/ND**   **NA/ND**     ***   ***   **NA/ND**   **NA/ND**     **NA/ND**     **NA/ND**
DYSPROSIUM       4.000E+00   4.600E+04   **NA/ND**     NO    ***   8.696E-05   **NA/ND**     0.0           **NA/ND**
HOLIMIUM         4.200E-01   **NA/ND**   **NA/ND**     ***   ***   **NA/ND**   **NA/ND**     **NA/ND**     **NA/ND**
ERBIUM           6.400E-01   **NA/ND**   **NA/ND**     ***   ***   **NA/ND**   **NA/ND**     **NA/ND**     **NA/ND**
THULIUM          2.200E-01   **NA/ND**   **NA/ND**     ***   ***   **NA/ND**   **NA/ND**     **NA/ND**     **NA/ND**
YTTERBIUM        3.700E-01   3.000E+03   **NA/ND**     NO    ***   1.233E-04   **NA/ND**     0.0           **NA/ND**
LUTETIUM         5.100E-01   **NA/ND**   **NA/ND**     ***   ***   **NA/ND**   **NA/ND**     **NA/ND**     **NA/ND**
HAFFNIUM         2.100E+00   1.500E+02   **NA/ND**     NO    ***   1.400E-02   **NA/ND**     0.0           **NA/ND**
TUNGSTEN         4.200E-01   3.000E+03   **NA/ND**     NO    ***   1.400E-04   **NA/ND**     0.0           **NA/ND**
RHENIUM          6.300E-01   **NA/ND**   **NA/ND**     ***   ***   **NA/ND**   **NA/ND**     **NA/ND**     **NA/ND**
OSMIUM           9.900E-01   **NA/ND**   **NA/ND**     ***   ***   **NA/ND**   **NA/ND**     **NA/ND**     **NA/ND**
IRIDIUM          9.100E-01   **NA/ND**   **NA/ND**     ***   ***   **NA/ND**   **NA/ND**     **NA/ND**     **NA/ND**
GOLD             5.900E-01   **NA/ND**   **NA/ND**     ***   ***   **NA/ND**   **NA/ND**     **NA/ND**     **NA/ND**
THALLIUM         4.900E-01   3.000E+02   **NA/ND**     NO    ***   1.633E-03   **NA/ND**     0.0           **NA/ND**
LEAD             8.400E+00   5.000E+01   1.000E+01     NO     NO   1.680E-01   8.400E-01     0.0           0.0
BISMUTH          4.000E-01   1.200E+03   **NA/ND**     NO    ***   3.333E-04   **NA/ND**     0.0           **NA/ND**
THORIUM          5.400E+00   1.300E+02   **NA/ND**     NO    ***   4.154E-02   **NA/ND**     0.0           **NA/ND**
URANIUM          1.300E+00   1.200E+04   1.000E+02     NO     NO   1.083E-04   1.300E-02     0.0           0.0
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                 SUBTOTAL INORGANIC DISCHARGE SEVERITY FROM THE EFFLUENT STREAM :


SUBTOTAL DISCHARGE SEVERITY (HEALTH DMEG BASED) =      1.175E+06
                             ECOLOGICAL
SUBTOTAL DISCHARGE SEVERITY (HEALTH DMEG BASED) =      6.494E+05


                 SUBTOTAL INORGANIC WEIGHTED DISCHARGE SEVERITY FROM THE EFFLUENT STREAM :


SUBTOTAL WEIGHTED DISCHARGE SEVERITY (HEALTH DMEG BASED) =       2.644E-01
SUBTOTAL WEIGHTED DISCHARGE SEVERITY (ECOLOGICAL DMEG BASED) =   2.468E-01
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                               SAM / 1A ANALYSIS :    INORGANIC EMISSIONS

     SAM / 1A, A SOURCE ANALYSIS MODEL ,WHICH IS BASED ON A COMPARISON OF DISCHARGE CONCENTRATIONS WITH A SET OF DISCHARGE
     MULTIMEDIA ENVIRONMENTAL GOALS (DMEG) CRITERIA ESTABLISHED BY THE U.S. E.P.A., IS USED FOR RAPID SCREENING OF EACH
     DISCHARGE STREAM FROM FLUIDIZED BED COAL COMBUSTION PROCESS.

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                                              BACKGROUND INFORMATION

     PROCESS CHARACTERISTICS      SOURCE :                          EXXON MINIPLANT WITH REGENERATION

                                  BED TEMPERATURE :                 894 C

                                  PRESSURE :                        760  KPA

                                  BED HEIGHT :                      3.10 M

                                  FLUIDIZING VELOCITY :             1.46 M/S

                                  COAL TYPE :                       CHAMPION

                                  SORBENT TYPE :                    GROVE LIMESTONE


     SAMPLING CHARACTERISTICS     TEST DATE :                       MAY 2 1979

                                  TEST NUMBER :                     01

                                  SAMPLING GROUP(S) :

                                  STREAM SAMPLED :                  EXXON COMB BED

                                  SAMPLING TECHNIQUE :              GRAB SAMPLES


     STREAM CHARACTERISTICS       STREAM ANALYZED :                 EX1-01-06-CB COMBUSTOR BD

                                  SAMPLE TYPE :                     BULK SOLID

                                  ANALYTICAL TECHNIQUE :            SPARK SOURCE MASS SP

                                  STREAM FLOW RATE :                0.0          (   GRAMS / SEC. )

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EX1-01-06-C8 COMBUSTOR 8D

N.B. POLLUTANT CONCENTRATIONS ARE QUOTED IN PARTS PER MILLION BY WEIGHT.
THESE ARE EQUIVALENT TO MICROGRAMS/GRAM PARTICULATES.

(**NA/ND** DENOTES DATA NOT AVAILBLE OR NOT DETERMINED)

POLLUTANT SPECIES	DISCHARGE CONCENTRATION	LAND DMEG		IF DMEG EXCEEDED		DISCHARGE SEVERITY		WEIGHTED DISCHARGE SEVERITY	
		(HEALTH)	(ECOLOGICAL)	(H)	(E)	(HEALTH)	(ECOLOGICAL)	(HEALTH)	(ECOLOGICAL)
	(MICROGRAMS/GRAM)	(MICROGRAMS/GRAM)						(GRAMS/SEC.)	
LITHIUM	1.700E-01	7.000E+01	7.500E+01	NO	NO	2.429E-03	2.267E-03	0.0	0.0
BERYLLIUM	9.000E-03	6.000E+00	1.100E+01	NO	NO	1.500E-03	8.182E-04	0.0	0.0
BORON	1.100E+00	9.300E+03	5.000E+03	NO	NO	1.183E-04	2.200E-04	0.0	0.0
FLUORINE	1.800E+01	7.500E+03	**NA/ND**	NO	***	2.400E-03	**NA/ND**	0.0	**NA/ND**
SODIUM	1.400E+01	1.600E+05	**NA/ND**	NO	***	8.750E-05	**NA/ND**	0.0	**NA/ND**
MAGNESIUM	4.100E+02	1.800E+04	1.700E+04	NO	NO	2.278E-02	2.412E-02	0.0	0.0
ALUMINIUM	1.800E+02	1.600E+04	2.000E+02	NO	NO	1.125E-02	9.000E-01	0.0	0.0
SILICON	1.000E+03	3.000E+04	**NA/ND**	NO	***	3.333E-02	**NA/ND**	0.0	**NA/ND**
PHOSPHORUS	3.000E+01	3.000E+03	1.000E-01	NO	YES	1.000E-02	3.000E+02	0.0	0.0
SULPHUR	7.000E+04	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
CHLORINE	3.100E+01	2.600E+05	**NA/ND**	NO	***	1.192E-04	**NA/ND**	0.0	**NA/ND**
POTASSIUM	2.600E+02	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
CALCIUM(ION)	4.400E+05	4.800E+04	3.200E+03	YES	YES	9.167E+00	1.375E+02	0.0	0.0
TITANIUM	2.900E+01	1.800E+04	1.600E+02	NO	NO	1.611E-03	1.812E-01	0.0	0.0
VANADIUM	1.200E+00	5.000E+02	3.000E+01	NO	NO	2.400E-03	4.000E-02	0.0	0.0
CHROMIUM	3.100E-01	5.000E+01	5.000E+01	NO	NO	6.200E-03	6.200E-03	0.0	0.0
MANGANESE	1.300E+01	5.000E+01	2.000E+01	NO	NO	2.600E-01	6.500E-01	0.0	0.0
IRON	4.300E+02	3.000E+02	5.000E+01	YES	YES	1.433E+00	8.600E+00	0.0	0.0
COBALT	1.100E-01	1.500E+02	5.000E+01	NO	NO	7.333E-04	2.200E-03	0.0	0.0
NICKEL	2.400E+00	4.500E+01	2.000E+00	NO	YES	5.333E-02	1.200E+00	0.0	0.0
COPPER	9.300E-01	1.000E+03	1.000E+01	NO	NO	9.300E-04	9.300E-02	0.0	0.0
ZINC	3.000E+00	5.000E+03	2.000E+01	NO	NO	6.000E-04	1.500E-01	0.0	0.0
GALLIUM	1.000E-01	1.500E+04	**NA/ND**	NO	***	6.667E-06	**NA/ND**	0.0	**NA/ND**
GERMANIUM	6.100E-02	1.700E+03	**NA/ND**	NO	***	3.588E-05	**NA/ND**	0.0	**NA/ND**
ARSENIC	2.500E+00	5.000E+01	1.000E+01	NO	NO	5.000E-02	2.500E-01	0.0	0.0
SELENIUM	9.400E-02	1.000E+01	5.000E+00	NO	NO	9.400E-03	1.880E-02	0.0	0.0
BROMINE	8.500E-01	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
RUBIDIUM	1.400E+00	3.600E+05	**NA/ND**	NO	***	3.889E-06	**NA/ND**	0.0	**NA/ND**
STRONTIUM	1.600E+02	9.200E+03	**NA/ND**	NO	***	1.739E-02	**NA/ND**	0.0	**NA/ND**
YTTRIUM	1.000E+00	3.000E+03	**NA/ND**	NO	***	3.333E-04	**NA/ND**	0.0	**NA/ND**
ZIRCONIUM	1.500E+00	1.500E+03	**NA/ND**	NO	***	1.000E-03	**NA/ND**	0.0	**NA/ND**
NIOBIUM	9.700E-02	6.500E+04	**NA/ND**	NO	***	1.492E-06	**NA/ND**	0.0	**NA/ND**
MOLYBDENUM	9.100E-02	1.500E+04	1.400E+03	NO	NO	6.067E-06	6.500E-05	0.0	0.0
RUTHENIUM	1.500E-01	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**

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POLLUTANT        DISCHARGE           LAND DMEG              IF          DISCHARGE SEVERITY              WEIGHTED
 SPECIES       CONCENTRATION                               DMEG                                         DISCHARGE
                                                         EXCEEDED                                       SEVERITY
                               (HEALTH)  (ECOLOGICAL)    (H)  (E)    (HEALTH)     (ECOLOGICAL)     (HEALTH)   (ECOLOGICAL)


                                                                                                        (GRAMS/SEC.)
             (MICROGRAMS/GRAM)   (MICROGRAMS/GRAM)

RHODIUM         4.800E-02    5.000E+00   **NA/ND**    NO   ***   1.600E-02    **NA/ND**       0.0          **NA/ND**
PALLADIUM       1.800E-01    **NA/ND**   **NA/ND**    ***  ***   **NA/ND**    **NA/ND**       **NA/ND**    **NA/ND**
CADMIUM         6.300E-02    1.000E+01   2.000E-01    NO    NO   6.300E-03    3.150E-01       0.0          0.0
INDIUM          **NA/ND**    3.000E+00   **NA/ND**    ***  ***   **NA/ND**    **NA/ND**       **NA/ND**    **NA/ND**
TIN             1.100E-01    **NA/ND**   **NA/ND**    ***  ***   **NA/ND**    **NA/ND**       **NA/ND**    **NA/ND**
ANTIMONY        9.600E-02    1.500E+03   4.000E+01    NO    NO   6.400E-05    2.400E-03       0.0          0.0
TELLURIUM       1.300E-01    3.000E+02   **NA/ND**    NO   ***   4.333E-04    **NA/ND**       0.0          **NA/ND**
IODINE          5.400E-01    **NA/ND**   **NA/ND**    ***  ***   **NA/ND**    **NA/ND**       **NA/ND**    **NA/ND**
CESIUM          2.000E-02    2.500E+05   **NA/ND**    NO   ***   8.000E-08    **NA/ND**       0.0          **NA/ND**
BARIUM          1.400E+01    1.000E+03   5.000E+02    NO    NO   1.400E-02    2.800E-02       0.0          0.0
LANTHANUM       4.600E-01    3.400E+05   **NA/ND**    NO   ***   1.353E-06    **NA/ND**       0.0          **NA/ND**
CERIUM          4.600E-01    1.100E+05   **NA/ND**    NO   ***   4.182E-06    **NA/ND**       0.0          **NA/ND**
PRASEODYMIUM    4.200E-02    1.500E+05   **NA/ND**    NO   ***   2.800E-07    **NA/ND**       0.0          **NA/ND**
NEODYMIUM       1.600E-01    **NA/ND**   **NA/ND**    ***  ***   **NA/ND**    **NA/ND**       **NA/ND**    **NA/ND**
SAMARIUM        2.300E-01    1.600E+05   **NA/ND**    NO   ***   1.438E-06    **NA/ND**       0.0          **NA/ND**
EUROPIUM        7.600E-02    **NA/ND**   **NA/ND**    ***  ***   **NA/ND**    **NA/ND**       **NA/ND**    **NA/ND**
GADOLINIUM      1.100E-01    **NA/ND**   **NA/ND**    ***  ***   **NA/ND**    **NA/ND**       **NA/ND**    **NA/ND**
TERBIUM         2.100E-02    **NA/ND**   **NA/ND**    ***  ***   **NA/ND**    **NA/ND**       **NA/ND**    **NA/ND**
DYSPROSIUM      1.100E-01    4.600E+04   **NA/ND**    NO   ***   2.391E-06    **NA/ND**       0.0          **NA/ND**
HOLIMIUM        3.200E-02    **NA/ND**   **NA/ND**    ***  ***   **NA/ND**    **NA/ND**       **NA/ND**    **NA/ND**
ERBIUM          1.900E-01    **NA/ND**   **NA/ND**    ***  ***   **NA/ND**    **NA/ND**       **NA/ND**    **NA/ND**
THULIUM         6.500E-02    **NA/ND**   **NA/ND**    ***  ***   **NA/ND**    **NA/ND**       **NA/ND**    **NA/ND**
YTTERBIUM       1.100E-01    3.000E+03   **NA/ND**    NO   ***   3.667E-05    **NA/ND**       0.0          **NA/ND**
LUTETIUM        1.500E-01    **NA/ND**   **NA/ND**    ***  ***   **NA/ND**    **NA/ND**       **NA/ND**    **NA/ND**
HAFNIUM         6.200E-01    1.500E+02   **NA/ND**    NO   ***   4.133E-03    **NA/ND**       0.0          **NA/ND**
TUNGSTEN        1.300E-01    3.000E+03   **NA/ND**    NO   ***   4.333E-05    **NA/ND**       0.0          **NA/ND**
RHENIUM         1.900E-01    **NA/ND**   **NA/ND**    ***  ***   **NA/ND**    **NA/ND**       **NA/ND**    **NA/ND**
OSMIUM          3.000E-01    **NA/ND**   **NA/ND**    ***  ***   **NA/ND**    **NA/ND**       **NA/ND**    **NA/ND**
IRIDIUM         2.700E-01    **NA/ND**   **NA/ND**    ***  ***   **NA/ND**    **NA/ND**       **NA/ND**    **NA/ND**
GOLD            1.800E-01    **NA/ND**   **NA/ND**    ***  ***   **NA/ND**    **NA/ND**       **NA/ND**    **NA/ND**
THALLIUM        1.500E-01    3.000E+02   **NA/ND**    NO   ***   5.000E-04    **NA/ND**       0.0          **NA/ND**
LEAD            5.500E-01    5.000E+01   1.000E+01    NO    NO   1.100E-02    5.500E-02       0.0          0.0
BISMUTH         1.200E-01    1.200E+03   **NA/ND**    NO   ***   1.000E-04    **NA/ND**       0.0          **NA/ND**
THORIUM         2.800E-01    1.300E+02   **NA/ND**    NO   ***   2.154E-03    **NA/ND**       0.0          **NA/ND**
URANIUM         2.000E-01    1.200E+04   1.000E+02    NO    NO   1.667E-05    2.000E-03       0.0          0.0
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                         EXI-01-06-CH COMBUSTOR 80

             SUBTOTAL INORGANIC DISCHARGE SEVERITY FROM THE EFFLUENT STREAM :


SUBTOTAL DISCHARGE SEVERITY (HEALTH DMEG BASED) =       1.114E+01
                             Ecological
SUBTOTAL DISCHARGE SEVERITY (HEALTH DMEG BASED) =       4.500E+02

             SUBTOTAL INORGANIC WEIGHTED DISCHARGE SEVERITY FROM THE EFFLUENT STREAM :


SUBTOTAL WEIGHTED DISCHARGE SEVERITY (HEALTH DMEG BASED) =        0.0
SUBTOTAL WEIGHTED DISCHARGE SEVERITY (ECOLOGICAL DMEG BASED) =    0.0
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                              SAM / 1A ANALYSIS :    INORGANIC EMISSIONS

SAM / 1A, A SOURCE ANALYSIS MODEL ,WHICH IS BASED ON A COMPARISON OF DISCHARGE CONCENTRATIONS WITH A SET OF DISCHARGE
MULTIMEDIA ENVIRONMENTAL GOALS (DMEG) CRITERIA ESTABLISHED BY THE U.S. E.P.A., IS USED FOR RAPID SCREENING OF EACH
DISCHARGE STREAM FROM FLUIDIZED BED COAL COMBUSTION PROCESS.

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                                        BACKGROUND INFORMATION

PROCESS CHARACTERISTICS      SOURCE :                        EXXON MINIPLANT WITH REGENERATION

                             BED TEMPERATURE :               894 C

                             PRESSURE :                      760  KPA

                             BED HEIGHT :                    5.10 M

                             FLUIDIZING VELOCITY :           1.46 M/S

                             COAL TYPE :                     CHAMPION

                             SORBENT TYPE :                  GROVE LIMESTONE


SAMPLING CHARACTERISTICS     TEST DATE :                     MAY 2 1979

                             TEST NUMBER :                   01

                             SAMPLING GROUP(S) :

                             STREAM SAMPLED :                EXXON SECOND CYCLONE

                             SAMPLING TECHNIQUE :            GRAB SAMPLES


STREAM CHARACTERISTICS       STREAM ANALYZED :               EX-01-07-FA2 EXX 2 CYCL H

                             SAMPLE TYPE :                   BLK SOLID

                             ANALYTICAL TECHNIQUE :          SPARK SOURCE MASS SP

                             STREAM FLOW RATE :              1.424E+00     (   GRAMS / SEC. )

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EX-01-07-FA2 FXX 2 CYCL B

N.B. POLLUTANT CONCENTRATIONS ARE QUOTED IN PARTS PER MILLION BY WEIGHT.
THESE ARE EQUIVALENT TO MICROGRAMS/GRAM PARTICULATES.

(**NA/ND** DENOTES DATA NOT AVAILBLE OR NOT DETERMINED)

POLLUTANT SPECIES	DISCHARGE CONCENTRATION	LAND DMEG		IF DMEG EXCEEDED		DISCHARGE SEVERITY		WEIGHTED DISCHARGE SEVERITY	
		(HEALTH)	(ECOLOGICAL)	(H)	(E)	(HEALTH)	(ECOLOGICAL)	(HEALTH)	(ECOLOGICAL)
	(MICROGRAMS/GRAM)	(MICROGRAMS/GRAM)						(GRAMS/SEC.)	
LITHIUM	1.300E+01	7.000E+01	7.500E+01	NO	NO	1.857E-01	1.733E-01	2.644E-01	2.468E-01
BERYLLIUM	3.700E+00	6.000E+00	1.100E+01	NO	NO	6.167E-01	3.364E-01	8.780E-01	4.789E-01
BORON	1.300E+03	9.300E+03	5.000E+03	NO	NO	1.398E-01	2.600E-01	1.990E-01	3.702E-01
FLUORINE	3.500E+02	7.500E+03	**NA/ND**	NO	***	4.667E-02	**NA/ND**	6.644E-02	**NA/ND**
SODIUM	2.700E+02	1.600E+05	**NA/ND**	NO	***	1.687E-03	**NA/ND**	2.403E-03	**NA/ND**
MAGNESIUM	1.400E+03	1.800E+04	1.700E+04	NO	NO	7.778E-02	8.235E-02	1.107E-01	1.173E-01
ALUMINIUM	3.300E+03	1.600E+04	2.000E+02	NO	YES	2.062E-01	1.650E+01	2.937E-01	2.349E+01
SILICON	1.000E+04	3.000E+04	**NA/ND**	NO	***	3.333E-01	**NA/ND**	4.746E-01	**NA/ND**
PHOSPHORUS	8.200E+02	3.000E+03	1.000E-01	NO	YES	2.733E-01	8.200E+03	3.892E-01	1.168E+04
SULPHUR	3.130E+04	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
CHLORINE	1.700E+03	2.600E+05	**NA/ND**	NO	***	6.538E-03	**NA/ND**	9.309E-03	**NA/ND**
POTASSIUM	3.500E+03	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
CALCIUM(ION)	1.400E+05	4.800E+04	3.200E+03	YES	YES	2.917E+00	4.375E+01	4.153E+00	6.229E+01
TITANIUM	4.300E+03	1.800E+04	1.600E+02	NO	YES	2.389E-01	2.688E+01	3.401E-01	3.826E+01
VANADIUM	1.300E+02	5.000E+02	3.000E+01	NO	YES	2.600E-01	4.333E+00	3.702E-01	6.170E+00
CHROMIUM	5.700E+01	5.000E+01	5.000E+01	YES	YES	1.140E+00	1.140E+00	1.623E+00	1.623E+00
MANGANESE	8.800E+01	5.000E+01	2.000E+01	YES	YES	1.760E+00	4.400E+00	2.506E+00	6.265E+00
IRON	1.000E+04	3.000E+02	5.000E+01	YES	YES	3.333E+01	2.000E+02	4.746E+01	2.848E+02
COBALT	2.900E+01	1.500E+02	5.000E+01	NO	NO	1.933E-01	5.800E-01	2.753E-01	8.258E-01
NICKEL	1.800E+02	4.500E+01	2.000E+00	YES	YES	4.000E+00	9.000E+01	5.695E+00	1.281E+02
COPPER	4.800E+01	1.000E+03	1.000E+01	NO	YES	4.800E-02	4.800E+00	6.834E-02	6.834E+00
ZINC	2.500E+02	5.000E+03	2.000E+01	NO	YES	5.000E-02	1.250E+01	7.119E-02	1.780E+01
GALLIUM	2.800E+01	1.500E+04	**NA/ND**	NO	***	1.867E-03	**NA/ND**	2.658E-03	**NA/ND**
GERMANIUM	1.200E+01	1.700E+03	**NA/ND**	NO	***	7.059E-03	**NA/ND**	1.005E-02	**NA/ND**
ARSENIC	1.400E+02	5.000E+01	1.000E+01	YES	YES	2.800E+00	1.400E+01	3.987E+00	1.993E+01
SELENIUM	6.400E-01	1.000E+01	5.000E+00	NO	NO	6.400E-02	1.280E-01	9.112E-02	1.822E-01
BROMINE	1.000E+01	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
RUBIDIUM	7.800E+01	3.600E+05	**NA/ND**	NO	***	2.167E-04	**NA/ND**	3.085E-04	**NA/ND**
STRONTIUM	5.200E+02	9.200E+03	**NA/ND**	NO	***	5.652E-02	**NA/ND**	8.048E-02	**NA/ND**
YTTRIUM	1.600E+02	3.000E+03	**NA/ND**	NO	***	5.333E-02	**NA/ND**	7.594E-02	**NA/ND**
ZIRCONIUM	2.700E+02	1.500E+03	**NA/ND**	NO	***	1.800E-01	**NA/ND**	2.563E-01	**NA/ND**
NIOBIUM	1.900E+01	6.500E+04	**NA/ND**	NO	***	2.923E-04	**NA/ND**	4.162E-04	**NA/ND**
MOLYBDENUM	8.900E+00	1.500E+04	1.400E+03	NO	NO	5.933E-04	6.357E-03	8.448E-04	9.051E-03
RUTHENIUM	2.400E+01	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**

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POLLUTANT         DISCHARGE             LAND DMEG               IF         DISCHARGE SEVERITY              WEIGHTED
 SPECIES        CONCENTRATION                                  DMEG                                       DISCHARGE
                                                             EXCEEDED                                      SEVERITY
                                  (HEALTH)    (ECOLOGICAL)  (H)  (E)    (HEALTH)       (ECOLOGICAL)    (HEALTH)   (ECOLOGICAL)


                 (MICROGRAMS/GRAM)   (MICROGRAMS/GRAM)                                                     (GRAMS/SEC.)


RHODIUM          7.800E-02    3.000E+00   **NA/ND**     NO   ***   2.600E-02     **NA/ND**      3.702E-02    **NA/ND**
PALLADIUM        4.200E-01    **NA/ND**   **NA/ND**     ***  ***   **NA/ND**     **NA/ND**      **NA/ND**    **NA/ND**
CADMIUM          6.600E-01    1.000E+01   2.000E-01     NO   YES   6.600E-02     3.300E+00      9.397E-02    4.699E+00
INDIUM           **NA/ND**    3.000E+00   **NA/ND**     ***  ***   **NA/ND**     **NA/ND**      **NA/ND**    **NA/ND**
TIN              4.500E+00    **NA/ND**   **NA/ND**     ***  ***   **NA/ND**     **NA/ND**      **NA/ND**    **NA/ND**
ANTIMONY         4.700E+00    1.500E+03   4.000E+01     NO    NO   3.133E-03     1.175E-01      4.461E-03    1.673E-01
TELLURIUM        3.900E-01    3.000E+02   **NA/ND**     NO   ***   1.300E-03     **NA/ND**      1.851E-03    **NA/ND**
IODINE           2.400E-01    **NA/ND**   **NA/ND**     ***  ***   **NA/ND**     **NA/ND**      **NA/ND**    **NA/ND**
CESIUM           2.700E+00    2.500E+05   **NA/ND**     NO   ***   1.080E-05     **NA/ND**      1.538E-05    **NA/ND**
BARIUM           4.200E+02    1.000E+03   5.000E+02     NO    NO   4.200E-01     8.400E-01      5.980E-01    1.196E+00
LANTHANUM        9.000E+01    3.400E+05   **NA/ND**     NO   ***   2.647E-04     **NA/ND**      3.769E-04    **NA/ND**
CERIUM           6.200E+01    1.100E+05   **NA/ND**     NO   ***   5.636E-04     **NA/ND**      8.025E-04    **NA/ND**
PRASEODYMIUM     8.300E+00    1.500E+05   **NA/ND**     NO   ***   5.533E-05     **NA/ND**      7.878E-05    **NA/ND**
NEODYMIUM        2.600E+01    **NA/ND**   **NA/ND**     ***  ***   **NA/ND**     **NA/ND**      **NA/ND**    **NA/ND**
SAMARIUM         9.400E+00    1.600E+05   **NA/ND**     NO   ***   5.875E-05     **NA/ND**      8.365E-05    **NA/ND**
EUROPIUM         1.100E+00    **NA/ND**   **NA/ND**     ***  ***   **NA/ND**     **NA/ND**      **NA/ND**    **NA/ND**
GADOLINIUM       1.400E+00    **NA/ND**   **NA/ND**     ***  ***   **NA/ND**     **NA/ND**      **NA/ND**    **NA/ND**
TERBIUM          2.800E-01    **NA/ND**   **NA/ND**     ***  ***   **NA/ND**     **NA/ND**      **NA/ND**    **NA/ND**
DYSPROSIUM       2.200E+00    4.600E+04   **NA/ND**     NO   ***   4.783E-05     **NA/ND**      6.809E-05    **NA/ND**
HOLIMIUM         5.600E-01    **NA/ND**   **NA/ND**     ***  ***   **NA/ND**     **NA/ND**      **NA/ND**    **NA/ND**
ERBIUM           2.200E+00    **NA/ND**   **NA/ND**     ***  ***   **NA/ND**     **NA/ND**      **NA/ND**    **NA/ND**
THULIUM          6.100E-01    **NA/ND**   **NA/ND**     ***  ***   **NA/ND**     **NA/ND**      **NA/ND**    **NA/ND**
YTTERBIUM        1.400E+00    3.000E+03   **NA/ND**     NO   ***   4.667E-04     **NA/ND**      6.644E-04    **NA/ND**
LUTETIUM         5.000E-01    **NA/ND**   **NA/ND**     ***  ***   **NA/ND**     **NA/ND**      **NA/ND**    **NA/ND**
HAFFNIUM         3.600E+00    1.500E+02   **NA/ND**     NO   ***   2.400E-02     **NA/ND**      3.417E-02    **NA/ND**
TUNGSTEN         4.100E-01    3.000E+03   **NA/ND**     NO   ***   1.367E-04     **NA/ND**      1.946E-04    **NA/ND**
RHENIUM          3.100E-01    **NA/ND**   **NA/ND**     ***  ***   **NA/ND**     **NA/ND**      **NA/ND**    **NA/ND**
OSMIUM           4.800E-01    **NA/ND**   **NA/ND**     ***  ***   **NA/ND**     **NA/ND**      **NA/ND**    **NA/ND**
IRIDIUM          4.500E-01    **NA/ND**   **NA/ND**     ***  ***   **NA/ND**     **NA/ND**      **NA/ND**    **NA/ND**
GOLD             2.900E-01    **NA/ND**   **NA/ND**     ***  ***   **NA/ND**     **NA/ND**      **NA/ND**    **NA/ND**
THALLIUM         2.600E+00    3.000E+02   **NA/ND**     NO   ***   8.667E-03     **NA/ND**      1.234E-02    **NA/ND**
LEAD             5.400E+01    5.000E+01   1.000E+01     YES  YES   1.080E+00     5.400E+00      1.538E+00    7.689E+00
BISMUTH          4.000E-01    1.200E+03   **NA/ND**     NO   ***   3.333E-04     **NA/ND**      4.746E-04    **NA/ND**
THORIUM          9.700E+00    1.300E+02   **NA/ND**     NO   ***   7.462E-02     **NA/ND**      1.062E-01    **NA/ND**
URANIUM          1.900E+00    1.200E+04   1.000E+02     NO    NO   1.583E-04     1.900E-02      2.254E-04    2.705E-02
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                    EX-01-07-FA2 EXX 2 CYCL B

          SUBTOTAL INORGANIC DISCHARGE SEVERITY FROM THE EFFLUENT STREAM :


SUBTOTAL DISCHARGE SEVERITY (HEALTH DMEG BASED) =       5.070E+01
                             ECOLOGICAL
SUBTOTAL DISCHARGE SEVERITY (HEALTH DMEG BASED) =       8.630E+03


          SUBTOTAL INORGANIC WEIGHTED DISCHARGE SEVERITY FROM THE EFFLUENT STREAM :


SUBTOTAL WEIGHTED DISCHARGE SEVERITY (HEALTH DMEG BASED) =        7.218E+01
SUBTOTAL WEIGHTED DISCHARGE SEVERITY (ECOLOGICAL DMEG BASED) =    1.229E+04
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                                        SAM / 1A ANALYSIS :    INORGANIC EMISSIONS

   SAM / 1A, A SOURCE ANALYSIS MODEL ,WHICH IS BASED ON A COMPARISON OF DISCHARGE CONCENTRATIONS WITH A SET OF DISCHARGE
   MULTIMEDIA ENVIRONMENTAL GOALS (DMEG) CRITERIA ESTABLISHED BY THE U.S. E.P.A., IS USED FOR RAPID SCREENING OF EACH
   DISCHARGE STREAM FROM FLUIDIZED BED COAL COMBUSTION PROCESS.

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                                                 BACKGROUND INFORMATION

   PROCESS CHARACTERISTICS     SOURCE :                           EXXON MINIPLANT WITH REGENERATION

                               BED TEMPERATURE :                  894 C

                               PRESSURE :                         760 KPA

                               BED HEIGHT :                       5.10 M

                               FLUIDIZING VELOCITY :              1.46 M/S

                               COAL TYPE :                        CHAMPION

                               SORBENT TYPE :                     GROVE LIMESTONE


   SAMPLING CHARACTERISTICS    TEST DATE :                        MAY 2 1979

                               TEST NUMBER :                      01

                               SAMPLING GROUP(S) :

                               STREAM SAMPLED :                   EXXON THIRD  CYCLONE

                               SAMPLING TECHNIQUE :               GRAB SAMPLES


   STREAM CHARACTERISTICS      STREAM ANALYZED :                  EX1-01-08-FAS

                               SAMPLE TYPE :                      BULK SOLID

                               ANALYTICAL TECHNIQUE :             SPARK SOURCE MASS SP

                               STREAM FLOW RATE :                 1.424E+00     (   GRAMS / SEC. )

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EXI-01-08-FA3

N.B. POLLUTANT CONCENTRATIONS ARE QUOTED IN PARTS PER MILLION BY WEIGHT.
THESE ARE EQUIVALENT TO MICROGRAMS/GRAM PARTICULATES.

(**NA/ND** DENOTES DATA NOT AVAILHLE OR NOT DETERMINED)

POLLUTANT SPECIES	DISCHARGE CONCENTRATION	LAND DMEG (HEALTH)	LAND DMEG (ECOLOGICAL)	IF DMEG EXCEEDED (H)	IF DMEG EXCEEDED (E)	DISCHARGE SEVERITY (HEALTH)	DISCHARGE SEVERITY (ECOLOGICAL)	WEIGHTED DISCHARGE SEVERITY (HEALTH)	WEIGHTED DISCHARGE SEVERITY (ECOLOGICAL)
	(MICROGRAMS/GRAM)	(MICROGRAMS/GRAM)						(GRAMS/SEC.)	
LITHIUM	3.800E+01	7.000E+01	7.500E+01	NO	NO	5.429E-01	5.067E-01	7.729E-01	7.214E-01
BERYLLIUM	3.600E+00	6.000E+00	1.100E+01	NO	NO	6.000E-01	3.273E-01	8.543E-01	4.660E-01
BORON	4.800E+02	9.500E+03	5.000E+03	NO	NO	5.161E-02	9.600E-02	7.349E-02	1.367E-01
FLUORINE	1.300E+02	7.500E+03	**NA/ND**	NO	***	1.733E-02	**NA/ND**	2.468E-02	**NA/ND**
SODIUM	8.000E+02	1.600E+05	**NA/ND**	NO	***	5.000E-03	**NA/ND**	7.119E-03	**NA/ND**
MAGNESIUM	1.500E+03	1.800E+04	1.700E+04	NO	NO	8.333E-02	8.824E-02	1.186E-01	1.256E-01
ALUMINIUM	9.500E+03	1.600E+04	2.000E+02	NO	YES	5.938E-01	4.750E+01	8.454E-01	6.763E+01
SILICON	1.000E+04	3.000E+04	**NA/ND**	NO	***	3.333E-01	**NA/ND**	4.746E-01	**NA/ND**
PHOSPHORUS	1.700E+03	3.000E+03	1.000E-01	NO	YES	5.667E-01	1.700E+04	8.068E-01	2.420E+04
SULPHUR	1.000E+04	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
CHLORINE	5.300E+02	2.600E+05	**NA/ND**	NO	***	2.038E-03	**NA/ND**	2.902E-03	**NA/ND**
POTASSIUM	3.600E+03	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
CALCIUM(ION)	1.100E+05	4.800E+04	3.200E+03	YES	YES	2.292E+00	3.438E+01	3.263E+00	4.894E+01
TITANIUM	8.700E+03	1.800E+04	1.600E+02	NO	YES	4.833E-01	5.438E+01	6.882E-01	7.742E+01
VANADIUM	2.600E+02	5.000E+02	3.000E+01	NO	YES	5.200E-01	8.667E+00	7.404E-01	1.234E+01
CHROMIUM	1.200E+02	5.000E+01	5.000E+01	YES	YES	2.400E+00	2.400E+00	3.417E+00	3.417E+00
MANGANESE	8.900E+01	5.000E+01	2.000E+01	YES	YES	1.780E+00	4.450E+00	2.534E+00	6.336E+00
IRON	1.000E+04	3.000E+02	5.000E+01	YES	YES	3.333E+01	2.000E+02	4.746E+01	2.848E+02
COBALT	4.200E+01	1.500E+02	5.000E+01	NO	NO	2.800E-01	8.400E-01	3.987E-01	1.196E+00
NICKEL	2.600E+02	4.500E+01	2.000E+00	YES	YES	5.778E+00	1.300E+02	8.226E+00	1.851E+02
COPPER	9.000E+01	1.000E+03	1.000E+01	NO	YES	9.000E-02	9.000E+00	1.281E-01	1.281E+01
ZINC	1.300E+02	5.000E+03	2.000E+01	NO	YES	2.600E-02	6.500E+00	3.702E-02	9.255E+00
GALLIUM	3.200E+01	1.500E+04	**NA/ND**	NO	***	2.133E-03	**NA/ND**	3.037E-03	**NA/ND**
GERMANIUM	1.400E+01	1.700E+03	**NA/ND**	NO	***	8.235E-03	**NA/ND**	1.173E-02	**NA/ND**
ARSENIC	6.700E+01	5.000E+01	1.000E+01	YES	YES	1.340E+00	6.700E+00	1.908E+00	9.539E+00
SELENIUM	8.000E+00	1.000E+01	5.000E+00	NO	YES	8.000E-01	1.600E+00	1.139E+00	2.278E+00
BROMINE	5.400E+00	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
RUBIDIUM	4.000E+01	3.600E+05	**NA/ND**	NO	***	1.111E-04	**NA/ND**	1.582E-04	**NA/ND**
STRONTIUM	1.100E+03	9.200E+03	**NA/ND**	NO	***	1.196E-01	**NA/ND**	1.702E-01	**NA/ND**
YTTRIUM	1.100E+02	3.000E+03	**NA/ND**	NO	***	3.667E-02	**NA/ND**	5.221E-02	**NA/ND**
ZIRCONIUM	5.500E+02	1.500E+03	**NA/ND**	NO	***	3.667E-01	**NA/ND**	5.221E-01	**NA/ND**
NIOBIUM	2.700E+01	6.500E+04	**NA/ND**	NO	***	4.154E-04	**NA/ND**	5.914E-04	**NA/ND**
MOLYBDENUM	6.100E+00	1.500E+04	1.400E+03	NO	NO	4.067E-04	4.357E-03	5.790E-04	6.204E-03
RUTHENIUM	2.000E+00	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**

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 POLLUTANT        DISCHARGE           LAND OMEG              IF          DISCHARGE SEVERITY              WEIGHTED
  SPECIES       CONCENTRATION                               OMEG                                        DISCHARGE
                                                          EXCEEDED                                       SEVERITY
                                  (HEALTH)   (ECOLOGICAL)  (H)  (E)   (HEALTH)       (ECOLOGICAL)     (HEALTH)   (ECOLOGICAL)


                (MICROGRAMS/GRAM)    (MICROGRAMS/GRAM)                                                      (GRAMS/SEC.)


RHODIUM         < 1.600E-01   3.000E+00    **NA/ND**     NO   *** < 5.333E-02   < **NA/ND**    < 7.594E-02   < **NA/ND**
PALLADIUM       < 6.100E-01   **NA/ND**    **NA/ND**     ***  *** < **NA/ND**   < **NA/ND**    < **NA/ND**   < **NA/ND**
CADMIUM           3.500E+00   1.000E+01    2.000E-01     NO   YES   3.500E-01     1.750E+01      4.983E-01     2.492E+01
INDIUM            **NA/ND**   3.000E+00    **NA/ND**     ***  ***   **NA/ND**     **NA/ND**      **NA/ND**     **NA/ND**
TIN               4.100E+00   **NA/ND**    **NA/ND**     ***  ***   **NA/ND**     **NA/ND**      **NA/ND**     **NA/ND**
ANTIMONY          4.800E+00   1.500E+03    4.000E+01     NO    NO   3.200E-03     1.200E-01      4.556E-03     1.709E-01
TELLURIUM       < 4.400E-01   3.000E+02    **NA/ND**     NO   *** < 1.467E-03   < **NA/ND**    < 2.088E-03   < **NA/ND**
IODINE            4.800E-01   **NA/ND**    **NA/ND**     ***  ***   **NA/ND**     **NA/ND**      **NA/ND**     **NA/ND**
CESIUM            3.900E+00   2.500E+05    **NA/ND**     NO   ***   1.560E-05     **NA/ND**      2.221E-05     **NA/ND**
BARIUM            8.500E+02   1.000E+03    5.000E+02     NO   YES   8.500E-01     1.700E+00      1.210E+00     2.420E+00
LANTHANUM         1.800E+02   3.400E+05    **NA/ND**     NO   ***   5.294E-04     **NA/ND**      7.538E-04     **NA/ND**
CERIUM            1.900E+02   1.100E+05    **NA/ND**     NO   ***   1.727E-03     **NA/ND**      2.459E-03     **NA/ND**
PRASEODYMIUM      1.700E+01   1.500E+05    **NA/ND**     NO   ***   1.133E-04     **NA/ND**      1.614E-04     **NA/ND**
NEODYMIUM         5.200E+01   **NA/ND**    **NA/ND**     ***  ***   **NA/ND**     **NA/ND**      **NA/ND**     **NA/ND**
SAMARIUM          2.200E+01   1.600E+05    **NA/ND**     NO   ***   1.375E-04     **NA/ND**      1.958E-04     **NA/ND**
EUROPIUM          4.100E+00   **NA/ND**    **NA/ND**     ***  ***   **NA/ND**     **NA/ND**      **NA/ND**     **NA/ND**
GADOLINIUM        8.600E+00   **NA/ND**    **NA/ND**     ***  ***   **NA/ND**     **NA/ND**      **NA/ND**     **NA/ND**
TERBIUM           1.100E+00   **NA/ND**    **NA/ND**     ***  ***   **NA/ND**     **NA/ND**      **NA/ND**     **NA/ND**
DYSPROSIUM        3.300E+00   4.600E+04    **NA/ND**     NO   ***   7.174E-05     **NA/ND**      1.021E-04     **NA/ND**
HOLIMIUM          1.600E+00   **NA/ND**    **NA/ND**     ***  ***   **NA/ND**     **NA/ND**      **NA/ND**     **NA/ND**
ERBIUM            5.100E+00   **NA/ND**    **NA/ND**     ***  ***   **NA/ND**     **NA/ND**      **NA/ND**     **NA/ND**
THULIUM           1.700E+00   **NA/ND**    **NA/ND**     ***  ***   **NA/ND**     **NA/ND**      **NA/ND**     **NA/ND**
YTTERBIUM         5.900E+00   3.000E+03    **NA/ND**     NO   ***   1.967E-03     **NA/ND**      2.800E-03     **NA/ND**
LUTETIUM          1.000E+00   **NA/ND**    **NA/ND**     ***  ***   **NA/ND**     **NA/ND**      **NA/ND**     **NA/ND**
HAFFNIUM          7.700E+00   1.500E+02    **NA/ND**     NO   ***   5.133E-02     **NA/ND**      7.309E-02     **NA/ND**
TUNGSTEN        < 4.200E-01   3.000E+03    **NA/ND**     NO   *** < 1.400E-04   < **NA/ND**    < 1.993E-04   < **NA/ND**
RHENIUM         < 6.200E-01   **NA/ND**    **NA/ND**     ***  *** < **NA/ND**   < **NA/ND**    < **NA/ND**   < **NA/ND**
OSMIUM          < 9.800E-01   **NA/ND**    **NA/ND**     ***  *** < **NA/ND**   < **NA/ND**    < **NA/ND**   < **NA/ND**
IRIDIUM         < 9.100E-01   **NA/ND**    **NA/ND**     ***  *** < **NA/ND**   < **NA/ND**    < **NA/ND**   < **NA/ND**
GOLD            < 5.900E-01   **NA/ND**    **NA/ND**     ***  *** < **NA/ND**   < **NA/ND**    < **NA/ND**   < **NA/ND**
THALLIUM          2.300E+00   3.000E+02    **NA/ND**     NO   ***   7.667E-03     **NA/ND**      1.092E-02     **NA/ND**
LEAD              6.300E+01   5.000E+01    1.000E+01     YES  YES   1.260E+00     6.300E+00      1.794E+00     8.970E+00
BISMUTH           8.000E-01   1.200E+03    **NA/ND**     NO   ***   6.667E-04     **NA/ND**      9.492E-04     **NA/ND**
THORIUM           2.800E+01   1.300E+02    **NA/ND**     NO   ***   2.154E-01     **NA/ND**      3.067E-01     **NA/ND**
URANIUM           1.000E+01   1.200E+04    1.000E+02     NO    NO   8.333E-04     1.000E-01      1.187E-03     1.424E-01
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                   EX1-01-08-FAS

          SUBTOTAL INORGANIC DISCHARGE SEVERITY FROM THE EFFLUENT STREAM :


SUBTOTAL DISCHARGE SEVERITY (HEALTH DMEG BASED) =      5.525E+01
                             ECOLOGICAL
SUBTOTAL DISCHARGE SEVERITY (~~HEALTH~~ DMEG BASED) =      1.753E+04

          SUBTOTAL INORGANIC WEIGHTED DISCHARGE SEVERITY FROM THE EFFLUENT STREAM :


SUBTOTAL WEIGHTED DISCHARGE SEVERITY (HEALTH DMEG BASED) =      < 7.867E+01
SUBTOTAL WEIGHTED DISCHARGE SEVERITY (ECOLOGICAL DMEG BASED) =  < 2.496E+04
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                                  SAM / IA ANALYSIS :    INORGANIC EMISSIONS

   SAM / IA, A SOURCE ANALYSIS MODEL ,WHICH IS BASED ON A COMPARISON OF DISCHARGE CONCENTRATIONS WITH A SET OF DISCHARGE
   MULTIMEDIA ENVIRONMENTAL GOALS (MEG) CRITERIA ESTABLISHED BY THE U.S. E.P.A., IS USED FOR RAPID SCREENING OF EACH
   DISCHARGE STREAM FROM FLUIDIZED BED COAL COMBUSTION PROCESS.

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                                               BACKGROUND INFORMATION

   PROCESS CHARACTERISTICS      SOURCE :                         EXXON MINIPLANT WITH REGENERATION

                                BED TEMPERATURE :                894 C

                                PRESSURE :                       700  KPA

                                BED HEIGHT :                     5.10 M

                                FLUIDIZING VELOCITY :            1.40 MS

                                COAL TYPE :                      CHAMPION

                                SORBENT TYPE :                   GROVE LIMESTONE


   SAMPLING CHARACTERISTICS     TEST DATE :                      MAY 2 1979

                                TEST NUMBER :                    01

                                SAMPLING GROUP(S) :

                                STREAM SAMPLED :                 SORBENT FEED

                                SAMPLING TECHNIQUE :             GRAB SAMPLES


   STREAM CHARACTERISTICS       STREAM ANALYZED :                EX1-01-10-SF SORBENT

                                SAMPLE TYPE :                    BULK SOLID

                                ANALYTICAL TECHNIQUE :           SPARK SOURCE MASS SP

                                STREAM FLOW RATE :               1.500E+00     (   GRAMS / SEC. )

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                                  EX1-01-10-SF SORBENT

                N.B.  POLLUTANT CONCENTRATIONS ARE QUOTED IN PARTS PER MILLION BY WEIGHT.
                      THESE ARE EQUIVALENT TO MICROGRAMS/GRAM PARTICULATES.


                      ( **NA/ND** DENOTES DATA NOT AVAILBLE OR NOT DETERMINED )

POLLUTANT        DISCHARGE            LAND DMEG               IF         DISCHARGE SEVERITY              WEIGHTED
 SPECIES       CONCENTRATION                                 DMEG                                        DISCHARGE
                                                           EXCEEDED                                      SEVERITY
                                  (HEALTH)   (ECOLOGICAL)  (H)  (E)   (HEALTH)     (ECOLOGICAL)     (HEALTH)   (ECOLOGICAL)


            (MICROGRAMS/GRAM)   (MICROGRAMS/GRAM)                                                      (GRAMS/SEC.)


LITHIUM          1.800E-01    7.000E+01   7.500E+01    NO   NO   2.571E-03    2.400E-03     3.857E-03    3.600E-03
BERYLLIUM        1.400E-02    6.000E+00   1.100E+01    NO   NO   2.333E-03    1.273E-03     3.500E-03    1.909E-03
BORON            5.300E+01    9.300E+03   5.000E+03    NO   NO   5.699E-03    1.060E-02     8.548E-03    1.590E-02
FLUORINE         2.000E+01    7.500E+03   **NA/ND**    NO   ***  2.667E-03    **NA/ND**     4.000E-03    **NA/ND**
SODIUM           3.100E+01    1.600E+05   **NA/ND**    NO   ***  1.937E-04    **NA/ND**     2.906E-04    **NA/ND**
MAGNESIUM        8.900E+02    1.800E+04   1.700E+04    NO   NO   4.944E-02    5.235E-02     7.417E-02    7.853E-02
ALUMINIUM        1.800E+02    1.600E+04   2.000E+02    NO   NO   1.125E-02    9.000E-01     1.687E-02    1.350E+00
SILICON          2.200E+03    3.000E+04   **NA/ND**    NO   ***  7.333E-02    **NA/ND**     1.100E-01    **NA/ND**
PHOSPHORUS       4.500E+01    3.000E+03   1.000E-01    NO   YES  1.500E-02    4.500E+02     2.250E-02    6.750E+02
SULPHUR          4.200E+02    **NA/ND**   **NA/ND**    ***  ***  **NA/ND**    **NA/ND**     **NA/ND**    **NA/ND**
CHLORINE         4.700E+01    2.600E+05   **NA/ND**    NO   ***  1.808E-04    **NA/ND**     2.712E-04    **NA/ND**
POTASSIUM        2.000E+02    **NA/ND**   **NA/ND**    ***  ***  **NA/ND**    **NA/ND**     **NA/ND**    **NA/ND**
CALCIUM(ION)     6.900E+05    4.800E+04   3.200E+03    YES  YES  1.438E+01    2.156E+02     2.156E+01    3.234E+02
TITANIUM         4.400E+01    1.800E+04   1.600E+02    NO   NO   2.444E-03    2.750E-01     3.667E-03    4.125E-01
VANADIUM         8.900E-01    5.000E+02   3.000E+01    NO   NO   1.780E-03    2.967E-02     2.670E-03    4.450E-02
CHROMIUM         3.900E-01    5.000E+01   5.000E+01    NO   NO   7.800E-03    7.800E-03     1.170E-02    1.170E-02
MANGANESE        2.000E+01    5.000E+01   2.000E+01    NO   NO   4.000E-01    1.000E+00     6.000E-01    1.500E+00
IRON             4.400E+02    3.000E+02   5.000E+01    YES  YES  1.467E+00    8.800E+00     2.200E+00    1.320E+01
COBALT           1.600E-01    1.500E+02   5.000E+01    NO   NO   1.067E-03    3.200E-03     1.600E-03    4.800E-03
NICKEL           2.000E+00    4.500E+01   2.000E+00    NO   NO   4.444E-02    1.000E+00     6.667E-02    1.500E+00
COPPER           1.400E+00    1.000E+03   1.000E+01    NO   NO   1.400E-03    1.400E-01     2.100E-03    2.100E-01
ZINC             4.600E+00    5.000E+03   2.000E+01    NO   NO   9.200E-04    2.300E-01     1.380E-03    3.450E-01
GALLIUM          1.600E-01    1.500E+04   **NA/ND**    NO   ***  1.067E-05    **NA/ND**     1.600E-05    **NA/ND**
GERMANIUM        9.300E-02    1.700E+03   **NA/ND**    NO   ***  5.471E-05    **NA/ND**     8.206E-05    **NA/ND**
ARSENIC          3.800E+00    5.000E+01   1.000E+01    NO   NO   7.600E-02    3.800E-01     1.140E-01    5.700E-01
SELENIUM         1.400E-01    1.000E+01   5.000E+00    NO   NO   1.400E-02    2.800E-02     2.100E-02    4.200E-02
BROMINE          1.300E+00    **NA/ND**   **NA/ND**    ***  ***  **NA/ND**    **NA/ND**     **NA/ND**    **NA/ND**
RUBIDIUM         1.100E+00    3.600E+05   **NA/ND**    NO   ***  3.056E-06    **NA/ND**     4.583E-06    **NA/ND**
STRONTIUM        2.400E+02    9.200E+03   **NA/ND**    NO   ***  2.609E-02    **NA/ND**     3.913E-02    **NA/ND**
YTTRIUM          1.600E+00    3.000E+03   **NA/ND**    NO   ***  5.333E-04    **NA/ND**     8.000E-04    **NA/ND**
ZIRCONIUM        2.300E+00    1.500E+03   **NA/ND**    NO   ***  1.533E-03    **NA/ND**     2.300E-03    **NA/ND**
NIOBIUM          2.100E-01    6.500E+04   **NA/ND**    NO   ***  3.231E-06    **NA/ND**     4.846E-06    **NA/ND**
MOLYBDENUM       1.900E-01    1.500E+04   1.400E+03    NO   NO   1.267E-05    1.357E-04     1.900E-05    2.036E-04
RUTHENIUM        2.200E-01    **NA/ND**   **NA/ND**    ***  ***  **NA/ND**    **NA/ND**     **NA/ND**    **NA/ND**
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POLLUTANT SPECIES	DISCHARGE CONCENTRATION	LAND DMEG		IF DMEG EXCEEDED		DISCHARGE SEVERITY		WEIGHTED DISCHARGE SEVERITY	
		(HEALTH)	(ECOLOGICAL)	(H)	(E)	(HEALTH)	(ECOLOGICAL)	(HEALTH)	(ECOLOGICAL)
	(MICROGRAMS/GRAM)	(MICROGRAMS/GRAM)						(GRAMS/SEC.)	
RHODIUM	7.200E-02	3.000E+00	**NA/ND**	NO	***	2.400E-02	**NA/ND**	3.600E-02	**NA/ND**
PALLADIUM	2.800E-01	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
CADMIUM	4.800E-02	1.000E+01	2.000E-01	NO	NO	4.800E-03	2.400E-01	7.200E-03	3.600E-01
INDIUM	**NA/ND**	3.000E+00	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
TIN	1.700E-01	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
ANTIMONY	1.400E-01	1.500E+03	4.000E+01	NO	NO	9.333E-05	3.500E-03	1.400E-04	5.250E-03
TELLURIUM	2.000E-01	3.000E+02	**NA/ND**	NO	***	6.667E-04	**NA/ND**	1.000E-03	**NA/ND**
IODINE	8.200E-01	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
CESIUM	3.000E-02	2.500E+05	**NA/ND**	NO	***	1.200E-07	**NA/ND**	1.800E-07	**NA/ND**
BARIUM	3.500E+01	1.000E+03	5.000E+02	NO	NO	3.500E-02	7.000E-02	5.250E-02	1.050E-01
LANTHANUM	6.900E-01	3.400E+05	**NA/ND**	NO	***	2.029E-06	**NA/ND**	3.044E-06	**NA/ND**
CERIUM	6.900E-01	1.100E+05	**NA/ND**	NO	***	6.273E-06	**NA/ND**	9.409E-06	**NA/ND**
PRASEODYMIUM	6.400E-02	1.500E+05	**NA/ND**	NO	***	4.267E-07	**NA/ND**	6.400E-07	**NA/ND**
NEODYMIUM	2.400E-01	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
SAMARIUM	3.500E-01	1.600E+05	**NA/ND**	NO	***	2.187E-06	**NA/ND**	3.281E-06	**NA/ND**
EUROPIUM	1.100E-01	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
GADOLINIUM	1.600E-01	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
TERBIUM	3.200E-02	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
DYSPROSIUM	1.700E-01	4.600E+04	**NA/ND**	NO	***	3.696E-06	**NA/ND**	5.543E-06	**NA/ND**
HOLIMIUM	4.800E-02	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
ERBIUM	2.900E-01	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
THULIUM	9.900E-02	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
YTTERBIUM	1.700E-01	3.000E+03	**NA/ND**	NO	***	5.667E-05	**NA/ND**	8.500E-05	**NA/ND**
LUTETIUM	2.300E-01	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
HAFFNIUM	9.300E-01	1.500E+02	**NA/ND**	NO	***	6.200E-03	**NA/ND**	9.300E-03	**NA/ND**
TUNGSTEN	1.900E-01	3.000E+03	**NA/ND**	NO	***	6.333E-05	**NA/ND**	9.500E-05	**NA/ND**
RHENIUM	2.800E-01	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
OSMIUM	4.300E-01	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
IRIDIUM	4.100E-01	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
GOLD	2.700E-01	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
THALLIUM	2.200E-01	3.000E+02	**NA/ND**	NO	***	7.333E-04	**NA/ND**	1.100E-03	**NA/ND**
LEAD	8.300E-01	5.000E+01	1.000E+01	NO	NO	1.660E-02	8.300E-02	2.490E-02	1.245E-01
BISMUTH	1.800E-01	1.200E+03	**NA/ND**	NO	***	1.500E-04	**NA/ND**	2.250E-04	**NA/ND**
THORIUM	4.300E-01	1.300E+02	**NA/ND**	NO	***	3.308E-03	**NA/ND**	4.962E-03	**NA/ND**
URANIUM	3.000E-01	1.200E+04	1.000E+02	NO	NO	2.500E-05	3.000E-03	3.750E-05	4.500E-03

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                        EXI-01-10-SF SORBENT

            SUBTOTAL INORGANIC DISCHARGE SEVERITY FROM THE EFFLUENT STREAM :


  SUBTOTAL DISCHARGE SEVERITY (HEALTH DMEG BASED) =       1.667E+01
  SUBTOTAL DISCHARGE SEVERITY (ECOL DMEG BASED) =       67.888E+01

            SUBTOTAL INORGANIC WEIGHTED DISCHARGE SEVERITY FROM THE EFFLUENT STREAM :


  SUBTOTAL WEIGHTED DISCHARGE SEVERITY (HEALTH DMEG BASED) =        2.501E+01
  SUBTOTAL WEIGHTED DISCHARGE SEVERITY (ECOLOGICAL DMEG BASED) =    1.018E+03
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                                  SAM / IA ANALYSIS :    INORGANIC EMISSIONS

    SAM / IA, A SOURCE ANALYSIS MODEL ,WHICH IS BASED ON A COMPARISON OF DISCHARGE CONCENTRATIONS WITH A SET OF DISCHARGE
    MULTIMEDIA ENVIRONMENTAL GOALS (DMEG) CRITERIA ESTABLISHED BY THE U.S. E.P.A., IS USED FOR RAPID SCREENING OF EACH
    DISCHARGE STREAM FROM FLUIDIZED BED COAL COMBUSTION PROCESS.

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                                          BACKGROUND INFORMATION

    PROCESS CHARACTERISTICS      SOURCE :                          EXXON MINIPLANT WITH REGENERATION

                                 BED TEMPERATURE :                 894 C

                                 PRESSURE :                        760 KPA

                                 BED HEIGHT :                      3.10 M

                                 FLUIDIZING VELOCITY :             1.46 M/S

                                 COAL TYPE :                       CHAMPION

                                 SORBENT TYPE :                    GROVE LIMESTONE


    SAMPLING CHARACTERISTICS     TEST DATE :                       MAY 2 1979

                                 TEST NUMBER :                     01

                                 SAMPLING GROUP(S) :

                                 STREAM SAMPLED :                  EXXON REGEN CYCLONE

                                 SAMPLING TECHNIQUE :              GRAB SAMPLES


    STREAM CHARACTERISTICS       STREAM ANALYZED :                 EX-01-05-FAR

                                 SAMPLE TYPE :                     ASTM-A LEACHATE

                                 ANALYTICAL TECHNIQUE :             SSMS/AAS

                                 STREAM FLOW RATE :                1.190E-02     (   LITERS / SEC. )

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                              EX-01-05-FAR

            N.B.  POLLUTANT CONCENTRATIONS ARE QUOTED IN PARTS PER MILLION BY WEIGHT. THESE HAVE BEEN CONVERTED
                  TO MICROGRAMS PER MILLILITER


                       ( **NA/ND** DENOTES DATA NOT AVAILBLE OR NOT DETERMINED )


PULLUTANT       DISCHARGE          WATER DMEG             IF         DISCHARGE SEVERITY              WEIGHTED
SPECIES       CONCENTRATION                              DMEG                                        DISCHARGE
                                                       EXCEEDED                                      SEVERITY
                             (HEALTH)   (ECOLOGICAL)   (H)  (E)   (HEALTH)      (ECOLOGICAL)     (HEALTH)   (ECOLOGICAL)


              (MICROGRAMS/ML)     (MICROGRAMS/ML)                                                      (LITERS/SEC.)


LITHIUM          **NA/ND**   3.300E+02   3.800E+02   ***  ***   **NA/ND**      **NA/ND**      **NA/ND**      **NA/ND**
BERYLLIUM      < 1.000E-03   3.000E+01   5.500E+01   NO    NO < 3.333E-05    < 1.818E-05    < 3.967E-07    < 2.164E-07
BORON            1.500E-01   4.700E+04   2.500E+04   NO    NO   3.191E-06      6.000E-06      3.798E-08      7.140E-08
FLUORINE         7.600E-02   3.800E+04   **NA/ND**   NO   ***   2.000E-06      **NA/ND**      2.380E-06      **NA/ND**
SODIUM         < 1.000E-03   8.000E+05   **NA/ND**   NO   *** < 1.250E-09    < **NA/ND**    < 1.487E-11    < **NA/ND**
MAGNESIUM        5.000E-03   9.000E+04   8.700E+04   NO    NO   5.556E-08      5.747E-08      6.611E-10      6.839E-10
ALUMINIUM      < 1.000E-03   8.000E+04   1.000E+03   NO    NO < 1.250E-08    < 1.000E-06    < 1.487E-10    < 1.190E-08
SILICON          7.100E-01   1.500E+05   **NA/ND**   NO   ***   4.733E-06      **NA/ND**      5.633E-08      **NA/ND**
PHOSPHORUS     < 1.000E-03   1.500E+04   5.000E-01   NO    NO < 6.667E-08    < 2.000E-03    < 7.933E-10    < 2.380E-05
SULPHUR          4.796E+02   **NA/ND**   **NA/ND**   ***  ***   **NA/ND**      **NA/ND**      **NA/ND**      **NA/ND**
CHLORINE         1.310E+00   1.300E+06   **NA/ND**   NO   ***   1.008E-06      **NA/ND**      1.199E-08      **NA/ND**
POTASSIUM      < 1.000E-03   **NA/ND**   **NA/ND**   ***  *** < **NA/ND**    < **NA/ND**    < **NA/ND**    < **NA/ND**
CALCIUM(ION)     1.440E+03   2.400E+05   1.600E+04   NO    NO   6.000E-03      9.000E-02      7.140E-05      1.071E-03
TITANIUM       < 1.000E-03   9.000E+04   8.200E+02   NO    NO < 1.111E-08    < 1.220E-06    < 1.322E-10    < 1.451E-08
VANADIUM       < 1.000E-03   2.500E+03   1.500E+02   NO    NO < 4.000E-07    < 6.667E-06    < 4.760E-09    < 7.933E-08
CHROMIUM         2.000E-03   2.500E+02   2.500E+02   NO    NO   8.000E-06      8.000E-06      9.520E-08      9.520E-08
MANGANESE      < 1.000E-03   2.500E+02   1.000E+02   NO    NO < 4.000E-06    < 1.000E-05    < 4.760E-08    < 1.190E-07
IRON           < 1.000E-03   1.500E+03   2.500E+02   NO    NO < 6.667E-07    < 4.000E-06    < 7.933E-09    < 4.760E-08
COBALT         < 1.000E-03   7.500E+02   2.500E+02   NO    NO < 1.333E-06    < 4.000E-06    < 1.587E-08    < 4.760E-08
NICKEL           9.100E-02   2.300E+02   1.000E+01   NO    NO   3.957E-04      9.100E-03      4.708E-06      1.083E-04
COPPER         < 1.000E-03   5.000E+03   5.000E+01   NO    NO < 2.000E-07    < 2.000E-05    < 2.380E-09    < 2.380E-07
ZINC           < 1.000E-03   2.500E+04   1.000E+02   NO    NO < 4.000E-08    < 1.000E-05    < 4.760E-10    < 1.190E-07
GALLIUM        < 1.000E-03   7.400E+04   **NA/ND**   NO   *** < 1.351E-08    < **NA/ND**    < 1.608E-10    < **NA/ND**
GERMANIUM      < 1.700E-02   8.400E+03   **NA/ND**   NO   *** < 2.024E-06    < **NA/ND**    < 2.408E-08    < **NA/ND**
ARSENIC          6.600E-02   2.500E+02   5.000E+01   NO    NO   2.640E-04      1.320E-03      3.142E-06      1.571E-05
SELENIUM         2.700E-02   5.000E+01   2.500E+01   NO    NO   5.400E-04      1.080E-03      6.426E-06      1.285E-05
BROMINE        < 3.000E-03   **NA/ND**   **NA/ND**   ***  *** < **NA/ND**    < **NA/ND**    < **NA/ND**    < **NA/ND**
RUBIDIUM       < 1.000E-03   1.800E+06   **NA/ND**   NO   *** < 5.556E-10    < **NA/ND**    < 6.611E-12    < **NA/ND**
STRONTIUM        2.097E+00   4.600E+04   **NA/ND**   NO   ***   4.559E-05      **NA/ND**      5.425E-07      **NA/ND**
YTTRIUM        < 1.000E-03   1.500E+04   **NA/ND**   NO   *** < 6.667E-08    < **NA/ND**    < 7.933E-10    < **NA/ND**
ZIRCONIUM      < 1.000E-03   7.500E+04   **NA/ND**   NO   *** < 1.333E-08    < **NA/ND**    < 1.587E-10    < **NA/ND**
NIOBIUM        < 1.000E-03   3.300E+05   **NA/ND**   NO   *** < 3.030E-09    < **NA/ND**    < 3.606E-11    < **NA/ND**
MOLYBDENUM     < 4.200E-02   7.500E+04   7.000E+03   NO    NO < 5.600E-07    < 6.000E-06    < 6.664E-09    < 7.140E-08
RUTHENIUM      < 2.000E-03   **NA/ND**   **NA/ND**   ***  *** < **NA/ND**    < **NA/ND**    < **NA/ND**    < **NA/ND**
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POLLUTANT        DISCHARGE          WATER DMEG              IF        DISCHARGE SEVERITY                WEIGHTED
 SPECIES       CONCENTRATION                               DMEG                                         DISCHARGE
                                                         EXCEEDED                                        SEVERITY
                                (HEALTH)   (ECOLOGICAL)  (H)  (E)   (HEALTH)       (ECOLOGICAL)     (HEALTH)  (ECOLOGICAL)


                (MICROGRAMS/ML)     (MICROGRAMS/ML)                                                        (LITERS/SEC.)


RHODIUM         < 1.000E-03   1.500E+01    **NA/ND**     NO   *** < 6.667E-05    < **NA/ND**     < 7.933E-07    < **NA/ND**
PALLADIUM       < 1.000E-03   **NA/ND**    **NA/ND**     ***  *** < **NA/ND**    < **NA/ND**     < **NA/ND**    < **NA/ND**
CADMIUM         < 1.000E-03   5.000E+01    1.000E+00     NO    NO < 2.000E-05    < 1.000E-03     < 2.380E-07    < 1.190E-05
INDIUM            NOT FOUND AS INPUT
TIN             < 7.000E-03   **NA/ND**    **NA/ND**     ***  *** < **NA/ND**    < **NA/ND**     < **NA/ND**    < **NA/ND**
ANTIMONY        < 1.000E-03   7.500E+03    2.000E+02     NO    NO < 1.333E-07    < 5.000E-06     < 1.587E-09    < 5.950E-08
TELLURIUM       < 2.000E-03   1.500E+03    **NA/ND**     NO   *** < 1.333E-06    < **NA/ND**     < 1.587E-08    < **NA/ND**
IODINE          < 2.000E-03   **NA/ND**    **NA/ND**     ***  *** < **NA/ND**    < **NA/ND**     < **NA/ND**    < **NA/ND**
CESIUM          < 1.000E-03   1.200E+06    **NA/ND**     NO   *** < 8.333E-10    < **NA/ND**     < 9.917E-12    < **NA/ND**
BARIUM            4.360E-01   5.000E+03    2.500E+03     NO    NO   8.720E-05      1.744E-04       1.038E-06      2.075E-06
LANTHANUM       < 1.000E-03   1.700E+06    **NA/ND**     NO   *** < 5.882E-10    < **NA/ND**     < 7.000E-12    < **NA/ND**
CERIUM          < 1.000E-03   5.500E+05    **NA/ND**     NO   *** < 1.818E-09    < **NA/ND**     < 2.164E-11    < **NA/ND**
PRASEODYMIUM    < 1.000E-03   7.700E+05    **NA/ND**     NO   *** < 1.299E-09    < **NA/ND**     < 1.545E-11    < **NA/ND**
NEODYMIUM       < 2.000E-03   **NA/ND**    **NA/ND**     ***  *** < **NA/ND**    < **NA/ND**     < **NA/ND**    < **NA/ND**
SAMARIUM        < 2.000E-03   7.900E+05    **NA/ND**     NO   *** < 2.532E-09    < **NA/ND**     < 3.013E-11    < **NA/ND**
EUROPIUM        < 1.000E-03   **NA/ND**    **NA/ND**     ***  *** < **NA/ND**    < **NA/ND**     < **NA/ND**    < **NA/ND**
GADOLINIUM      < 1.000E-03   **NA/ND**    **NA/ND**     ***  *** < **NA/ND**    < **NA/ND**     < **NA/ND**    < **NA/ND**
TERBIUM         < 1.000E-03   **NA/ND**    **NA/ND**     ***  *** < **NA/ND**    < **NA/ND**     < **NA/ND**    < **NA/ND**
DYSPROSIUM      < 1.000E-03   2.300E+05    **NA/ND**     NO   *** < 4.348E-09    < **NA/ND**     < 5.174E-11    < **NA/ND**
HOLIMIUM        < 1.000E-03   **NA/ND**    **NA/ND**     ***  *** < **NA/ND**    < **NA/ND**     < **NA/ND**    < **NA/ND**
ERBIUM          < 2.000E-03   **NA/ND**    **NA/ND**     ***  *** < **NA/ND**    < **NA/ND**     < **NA/ND**    < **NA/ND**
THULIUM         < 1.000E-03   **NA/ND**    **NA/ND**     ***  *** < **NA/ND**    < **NA/ND**     < **NA/ND**    < **NA/ND**
YTTERBIUM       < 1.000E-03   1.500E+04    **NA/ND**     NO   *** < 6.667E-08    < **NA/ND**     < 7.933E-10    < **NA/ND**
LUTETIUM        < 1.000E-03   **NA/ND**    **NA/ND**     ***  *** < **NA/ND**    < **NA/ND**     < **NA/ND**    < **NA/ND**
HAFFNIUM        < 3.000E-03   7.500E+04    **NA/ND**     NO   *** < 4.000E-08    < **NA/ND**     < 4.760E-10    < **NA/ND**
TUNGSTEN        < 3.000E-03   1.500E+04    **NA/ND**     NO   *** < 2.000E-07    < **NA/ND**     < 2.380E-09    < **NA/ND**
RHENIUM         < 2.000E-03   **NA/ND**    **NA/ND**     ***  *** < **NA/ND**    < **NA/ND**     < **NA/ND**    < **NA/ND**
OSMIUM          < 3.000E-03   **NA/ND**    **NA/ND**     ***  *** < **NA/ND**    < **NA/ND**     < **NA/ND**    < **NA/ND**
IRIDIUM         < 3.000E-03   3.000E+01    **NA/ND**     NO   *** < 1.000E-04    < **NA/ND**     < 1.190E-06    < **NA/ND**
GOLD            < 2.000E-03   **NA/ND**    **NA/ND**     ***  *** < **NA/ND**    < **NA/ND**     < **NA/ND**    < **NA/ND**
THALLIUM        < 1.000E-03   1.500E+03    **NA/ND**     NO   *** < 6.667E-07    < **NA/ND**     < 7.933E-09    < **NA/ND**
LEAD              1.700E-02   2.500E+02    5.000E+01     NO    NO   6.800E-05      3.400E-04       8.092E-07      4.046E-06
BISMUTH         < 1.000E-03   6.100E+03    **NA/ND**     NO   *** < 1.639E-07    < **NA/ND**     < 1.951E-09    < **NA/ND**
THORIUM         < 3.000E-03   6.300E+03    **NA/ND**     NO   *** < 4.762E-07    < **NA/ND**     < 5.667E-09    < **NA/ND**
URANIUM         < 2.000E-03   6.000E+04    5.000E+02     NO    NO < 3.333E-08    < 4.000E-06     < 3.967E-10    < 4.760E-08
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                          EX-01-05-FAR

          SUBTOTAL INORGANIC DISCHARGE SEVERITY FROM THE EFFLUENT STREAM :


SUBTOTAL DISCHARGE SEVERITY (HEALTH DMEG BASED) =       7.652E-03
                             ECOLOGICAL
SUBTOTAL DISCHARGE SEVERITY (HEALTH DMEG BASED) =       1.051E-01

          SUBTOTAL INORGANIC WEIGHTED DISCHARGE SEVERITY FROM THE EFFLUENT STREAM :


SUBTOTAL WEIGHTED DISCHARGE SEVERITY (HEALTH DMEG BASED) =      < 9.106E-05
SUBTOTAL WEIGHTED DISCHARGE SEVERITY (ECOLOGICAL DMEG BASED) =  < 1.251E-03
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                              SAM / IA ANALYSIS :    INORGANIC EMISSIONS

SAM / IA, A SOURCE ANALYSIS MODEL ,WHICH IS BASED ON A COMPARISON OF DISCHARGE CONCENTRATIONS WITH A SET OF DISCHARGE
MULTIMEDIA ENVIRONMENTAL GOALS (DMEG) CRITERIA ESTABLISHED BY THE U.S. E.P.A., IS USED FOR RAPID SCREENING OF EACH
DISCHARGE STREAM FROM FLUIDIZED BED COAL COMBUSTION PROCESS.

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                                        BACKGROUND INFORMATION

PROCESS CHARACTERISTICS     SOURCE :                      EXXON MINIPLANT WITH REGENERATION

                            BED TEMPERATURE :             894 C

                            PRESSURE :                    760 KPA

                            BED HEIGHT :                  5.10 M

                            FLUIDIZING VELOCITY :         1.46 M/S

                            COAL TYPE :                   CHAMPION

                            SORBENT TYPE :                GROVE LIMESTONE


SAMPLING CHARACTERISTICS    TEST DATE :                   MAY 2 1979

                            TEST NUMBER :                 01

                            SAMPLING GROUP(S) :

                            STREAM SAMPLED :              EXXON COMB BED

                            SAMPLING TECHNIQUE :          GRAB SAMPLES


STREAM CHARACTERISTICS      STREAM ANALYZED :             EX1-01-06-CB

                            SAMPLE TYPE :                 ASTM-A LEACHATE

                            ANALYTICAL TECHNIQUE :          SSMS/AAS

                            STREAM FLOW RATE :            0.0          (   LITERS / SEC. )

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EXI-01-06-CB

N.B. POLLUTANT CONCENTRATIONS ARE QUOTED IN PARTS PER MILLION BY WEIGHT. THESE HAVE BEEN CONVERTED TO MICROGRAMS PER MILLILITER

(**NA/ND** DENOTES DATA NOT AVAILBLE OR NOT DETERMINED)

POLLUTANT SPECIES	DISCHARGE CONCENTRATION (MICROGRAMS/ML)	WATER DMEG (HEALTH) (MICROGRAMS/ML)	WATER DMEG (ECOLOGICAL)	IF DMEG EXCEEDED (H)	IF DMEG EXCEEDED (E)	DISCHARGE SEVERITY (HEALTH)	DISCHARGE SEVERITY (ECOLOGICAL)	WEIGHTED DISCHARGE SEVERITY (HEALTH)	WEIGHTED DISCHARGE SEVERITY (ECOLOGICAL) (LITERS/SEC.)
LITHIUM	1.200E-02	3.300E+02	3.800E+02	NO	NO	3.636E-05	3.158E-05	0.0	0.0
BERYLLIUM	< 1.000E-03	3.000E+01	5.500E+01	NO	NO	< 3.333E-05	< 1.818E-05	< 0.0	< 0.0
BORON	9.000E-03	4.700E+04	2.500E+04	NO	NO	1.915E-07	3.600E-07	0.0	0.0
FLUORINE	< 1.000E-03	3.800E+04	**NA/ND**	NO	***	< 2.632E-08	< **NA/ND**	< 0.0	< **NA/ND**
SODIUM	5.000E-02	8.000E+05	**NA/ND**	NO	***	6.250E-08	**NA/ND**	0.0	**NA/ND**
MAGNESIUM	2.300E-02	9.000E+04	8.700E+04	NO	NO	2.556E-07	2.644E-07	0.0	0.0
ALUMINIUM	1.050E-01	8.000E+04	1.000E+03	NO	NO	1.312E-06	1.050E-04	0.0	0.0
SILICON	< 1.000E-03	1.500E+05	**NA/ND**	NO	***	< 6.667E-09	< **NA/ND**	< 0.0	< **NA/ND**
PHOSPHORUS	< 1.000E-03	1.500E+04	5.000E-01	NO	NO	< 6.667E-08	< 2.000E-03	< 0.0	< 0.0
SULPHUR	1.196E+02	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
CHLORINE	< 1.000E-03	1.300E+06	**NA/ND**	NO	***	< 7.692E-10	< **NA/ND**	< 0.0	< **NA/ND**
POTASSIUM	8.300E-01	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
CALCIUM(ION)	6.400E+02	2.400E+05	1.600E+04	NO	NO	2.667E-03	4.000E-02	0.0	0.0
TITANIUM	< 1.000E-03	9.000E+04	8.200E+02	NO	NO	< 1.111E-08	< 1.220E-06	< 0.0	< 0.0
VANADIUM	9.000E-03	2.500E+03	1.500E+02	NO	NO	3.600E-06	6.000E-05	0.0	0.0
CHROMIUM	5.000E-03	2.500E+02	2.500E+02	NO	NO	2.000E-05	2.000E-05	0.0	0.0
MANGANESE	< 1.000E-03	2.500E+02	1.000E+02	NO	NO	< 4.000E-06	< 1.000E-05	< 0.0	< 0.0
IRON	< 1.000E-03	1.500E+03	2.500E+02	NO	NO	< 6.667E-07	< 4.000E-06	< 0.0	< 0.0
COBALT	**NA/ND**	7.500E+02	2.500E+02	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
NICKEL	2.000E-03	2.300E+02	1.000E+01	NO	NO	8.696E-06	2.000E-04	0.0	0.0
COPPER	6.000E-03	5.000E+03	5.000E+01	NO	NO	1.200E-06	1.200E-04	0.0	0.0
ZINC	1.030E-01	2.500E+04	1.000E+02	NO	NO	4.120E-06	1.030E-03	0.0	0.0
GALLIUM	< 1.000E-03	7.400E+04	**NA/ND**	NO	***	< 1.351E-08	< **NA/ND**	< 0.0	< **NA/ND**
GERMANIUM	< 2.000E-01	8.400E+03	**NA/ND**	NO	***	< 2.381E-05	< **NA/ND**	< 0.0	< **NA/ND**
ARSENIC	2.800E-02	2.500E+02	5.000E+01	NO	NO	1.120E-04	5.600E-04	0.0	0.0
SELENIUM	2.400E-02	5.000E+01	2.500E+01	NO	NO	4.800E-04	9.600E-04	0.0	0.0
BROMINE	< 1.300E-02	**NA/ND**	**NA/ND**	***	***	< **NA/ND**	< **NA/ND**	< **NA/ND**	< **NA/ND**
RUBIDIUM	7.000E-03	1.800E+06	**NA/ND**	NO	***	3.889E-09	**NA/ND**	0.0	**NA/ND**
STRONTIUM	2.000E+00	4.600E+04	**NA/ND**	NO	***	4.348E-05	**NA/ND**	0.0	**NA/ND**
YTTRIUM	< 1.000E-03	1.500E+04	**NA/ND**	NO	***	< 6.667E-08	< **NA/ND**	< 0.0	< **NA/ND**
ZIRCONIUM	< 1.000E-03	7.500E+04	**NA/ND**	NO	***	< 1.333E-08	< **NA/ND**	< 0.0	< **NA/ND**
NIOBIUM	< 1.000E-03	3.300E+05	**NA/ND**	NO	***	< 3.030E-09	< **NA/ND**	< 0.0	< **NA/ND**
MOLYBDENUM	< 1.100E-02	7.500E+04	7.000E+03	NO	NO	< 1.467E-07	< 1.571E-06	< 0.0	< 0.0
RUTHENIUM	< 1.000E-03	**NA/ND**	**NA/ND**	***	***	< **NA/ND**	< **NA/ND**	< **NA/ND**	< **NA/ND**

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POLLUTANT       DISCHARGE           WATER OMEG                 IF          DISCHARGE SEVERITY                  WEIGHTED
 SPECIES      CONCENTRATION                                   OMEG                                             DISCHARGE
                                                            EXCEEDED                                           SEVERITY
                              (HEALTH)    (ECOLOGICAL)      (H)  (E)    (HEALTH)       (ECOLOGICAL)      (HEALTH)   (ECOLOGICAL)


              (MICROGRAMS/ML)     (MICROGRAMS/ML)                                                              (LITERS/SEC.)


RHODIUM        < 1.000E-03    1.500E+01    **NA/ND**        NO   *** < 6.667E-05   < **NA/ND**      < 0.0            < **NA/ND**
PALLADIUM      < 1.000E-03    **NA/ND**    **NA/ND**        ***  *** < **NA/ND**   < **NA/ND**      < **NA/ND**      < **NA/ND**
CADMIUM        < 1.000E-03    5.000E+01    1.000E+00        NO    NO < 2.000E-05   < 1.000E-03      < 0.0            < 0.0
INDIUM          NOT FOUND AS INPUT
TIN            < 1.000E-03    **NA/ND**    **NA/ND**        ***  *** < **NA/ND**   < **NA/ND**      < **NA/ND**      < **NA/ND**
ANTIMONY       < 1.000E-03    7.500E+03    2.000E+02        NO    NO < 1.333E-07   < 5.000E-06      < 0.0            < 0.0
TELLURIUM      < 1.000E-03    1.500E+03    **NA/ND**        NO   *** < 6.667E-07   < **NA/ND**      < 0.0            < **NA/ND**
IODINE         < 2.000E-03    **NA/ND**    **NA/ND**        ***  *** < **NA/ND**   < **NA/ND**      < **NA/ND**      < **NA/ND**
CESIUM         < 1.000E-03    1.200E+06    **NA/ND**        NO   *** < 8.333E-10   < **NA/ND**      < 0.0            < **NA/ND**
BARIUM           3.720E-01    5.000E+03    2.500E+03        NO    NO   7.440E-05     1.488E-04        0.0              0.0
LANTHANUM      < 1.000E-03    1.700E+06    **NA/ND**        NO   *** < 5.882E-10   < **NA/ND**      < 0.0            < **NA/ND**
CERIUM         < 1.000E-03    5.500E+05    **NA/ND**        NO   *** < 1.818E-09   < **NA/ND**      < 0.0            < **NA/ND**
PRASEODYMIUM   < 1.000E-03    7.700E+05    **NA/ND**        NO   *** < 1.299E-09   < **NA/ND**      < 0.0            < **NA/ND**
NEODYMIUM      < 2.000E-03    **NA/ND**    **NA/ND**        ***  *** < **NA/ND**   < **NA/ND**      < **NA/ND**      < **NA/ND**
SAMARIUM       < 2.000E-03    7.900E+05    **NA/ND**        NO   *** < 2.532E-09   < **NA/ND**      < 0.0            < **NA/ND**
EUROPIUM       < 1.000E-03    **NA/ND**    **NA/ND**        ***  *** < **NA/ND**   < **NA/ND**      < **NA/ND**      < **NA/ND**
GADOLINIUM     < 1.000E-03    **NA/ND**    **NA/ND**        ***  *** < **NA/ND**   < **NA/ND**      < **NA/ND**      < **NA/ND**
TERBIUM        < 1.000E-03    **NA/ND**    **NA/ND**        ***  *** < **NA/ND**   < **NA/ND**      < **NA/ND**      < **NA/ND**
DYSPROSIUM     < 1.000E-03    2.300E+05    **NA/ND**        NO   *** < 4.348E-09   < **NA/ND**      < 0.0            < **NA/ND**
HOLIMIUM       < 1.000E-03    **NA/ND**    **NA/ND**        ***  *** < **NA/ND**   < **NA/ND**      < **NA/ND**      < **NA/ND**
ERBIUM         < 2.000E-03    **NA/ND**    **NA/ND**        ***  *** < **NA/ND**   < **NA/ND**      < **NA/ND**      < **NA/ND**
THULIUM        < 1.000E-03    **NA/ND**    **NA/ND**        ***  *** < **NA/ND**   < **NA/ND**      < **NA/ND**      < **NA/ND**
YTTERBIUM      < 1.000E-03    1.500E+04    **NA/ND**        NO   *** < 6.667E-08   < **NA/ND**      < 0.0            < **NA/ND**
LUTETIUM       < 1.000E-03    **NA/ND**    **NA/ND**        ***  *** < **NA/ND**   < **NA/ND**      < **NA/ND**      < **NA/ND**
HAFFNIUM       < 3.000E-03    7.500E+04    **NA/ND**        NO   *** < 4.000E-08   < **NA/ND**      < 0.0            < **NA/ND**
TUNGSTEN       < 3.000E-03    1.500E+04    **NA/ND**        NO   *** < 2.000E-07   < **NA/ND**      < 0.0            < **NA/ND**
RHENIUM        < 2.000E-03    **NA/ND**    **NA/ND**        ***  *** < **NA/ND**   < **NA/ND**      < **NA/ND**      < **NA/ND**
OSMIUM         < 3.000E-03    **NA/ND**    **NA/ND**        ***  *** < **NA/ND**   < **NA/ND**      < **NA/ND**      < **NA/ND**
IRIDIUM        < 3.000E-03    3.000E+01    **NA/ND**        NO   *** < 1.000E-04   < **NA/ND**      < 0.0            < **NA/ND**
GOLD           < 2.000E-03    **NA/ND**    **NA/ND**        ***  *** < **NA/ND**   < **NA/ND**      < **NA/ND**      < **NA/ND**
THALLIUM       < 1.000E-03    1.500E+03    **NA/ND**        NO   *** < 6.667E-07   < **NA/ND**      < 0.0            < **NA/ND**
LEAD             1.200E-02    2.500E+02    5.000E+01        NO    NO   4.800E-05     2.400E-04        0.0              0.0
BISMUTH        < 1.000E-03    6.100E+03    **NA/ND**        NO   *** < 1.639E-07   < **NA/ND**      < 0.0            < **NA/ND**
THORIUM        < 3.000E-03    6.300E+03    **NA/ND**        NO   *** < 4.762E-07   < **NA/ND**      < 0.0            < **NA/ND**
URANIUM        < 2.000E-03    6.000E+04    5.000E+02        NO    NO < 3.333E-08   < 4.000E-06      < 0.0            < 0.0
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                      EXI-01-06-C8

               SUBTOTAL INORGANIC DISCHARGE SEVERITY FROM THE EFFLUENT STREAM :


SUBTOTAL DISCHARGE SEVERITY (HEALTH DMEG BASED) =      3.753E-05
                             ECOLOGICAL
SUBTOTAL DISCHARGE SEVERITY (HEALTH DMEG BASED) =      4.652E-02

               SUBTOTAL INORGANIC WEIGHTED DISCHARGE SEVERITY FROM THE EFFLUENT STREAM :


SUBTOTAL WEIGHTED DISCHARGE SEVERITY (HEALTH DMEG BASED) =      < 1.587E-08
SUBTOTAL WEIGHTED DISCHARGE SEVERITY (ECOLOGICAL DMEG BASED) =  < 4.760E-08
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                                   SAM / 1A ANALYSIS :    INORGANIC EMISSIONS

    SAM / 1A, A SOURCE ANALYSIS MODEL ,WHICH IS BASED ON A COMPARISON OF DISCHARGE CONCENTRATIONS WITH A SET OF DISCHARGE
    MULTIMEDIA ENVIRONMENTAL GOALS (DMEG) CRITERIA ESTABLISHED BY THE U.S. E.P.A., IS USED FOR RAPID SCREENING OF EACH
    DISCHARGE STREAM FROM FLUIDIZED BED COAL COMBUSTION PROCESS.

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                                              BACKGROUND INFORMATION

    PROCESS CHARACTERISTICS     SOURCE :                        EXXON MINIPLANT WITH REGENERATION

                                BED TEMPERATURE :               894 C

                                PRESSURE :                      760 KPA

                                BED HEIGHT :                    5.10 M

                                FLUIDIZING VELOCITY :           1.46 M/S

                                COAL TYPE :                     CHAMPION

                                SORBENT TYPE :                  GROVE LIMESTONE

    SAMPLING CHARACTERISTICS    TEST DATE :                     MAY 2 1979

                                TEST NUMBER :                   01

                                SAMPLING GROUP(S) :

                                STREAM SAMPLED :                EXXON SECOND CYCLONE

                                SAMPLING TECHNIQUE :            GRAB SAMPLES

    STREAM CHARACTERISTICS      STREAM ANALYZED :               EX-01-07FA2

                                SAMPLE TYPE :                   ASTM-A LEACHATE

                                ANALYTICAL TECHNIQUE :            SSMS/AAS

                                STREAM FLOW RATE :              7.110E-02     (   LITERS / SEC. )

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FX-01-07FA2

N.B. POLLUTANT CONCENTRATIONS ARE QUOTED IN PARTS PER MILLION BY WEIGHT. THESE HAVE BEEN CONVERTED TO MICROGRAMS PER MILLILITER

(**NA/ND** DENOTES DATA NOT AVAILBLE OR NOT DETERMINED)

POLLUTANT SPECIES	DISCHARGE CONCENTRATION	WATER DMEG		IF DMEG EXCEEDED		DISCHARGE SEVERITY		WEIGHTED DISCHARGE SEVERITY	
		(HEALTH)	(ECOLOGICAL)	(H)	(E)	(HEALTH)	(ECOLOGICAL)	(HEALTH)	(ECOLOGICAL)
	(MICROGRAMS/ML)	(MICROGRAMS/ML)						(LITERS/SEC.)	
LITHIUM	2.100E-01	3.300E+02	3.800E+02	NO	NO	6.364E-04	5.526E-04	4.525E-05	3.929E-05
BERYLLIUM	< 1.000E-03	3.000E+01	5.500E+01	NO	NO	< 3.333E-05	< 1.818E-05	< 2.370E-06	< 1.293E-06
BORON	3.000E-01	4.700E+04	2.500E+04	NO	NO	6.383E-06	1.200E-05	4.538E-07	8.532E-07
FLUORINE	7.800E-02	3.800E+04	**NA/ND**	NO	***	2.053E-06	**NA/ND**	1.459E-07	**NA/ND**
SODIUM	1.179E+01	8.000E+05	**NA/ND**	NO	***	1.474E-05	**NA/ND**	1.048E-06	**NA/ND**
MAGNESIUM	1.400E-02	9.000E+04	8.700E+04	NO	NO	1.556E-07	1.609E-07	1.106E-08	1.144E-08
ALUMINIUM	< 1.000E-03	8.000E+04	1.000E+03	NO	NO	< 1.250E-08	< 1.000E-06	< 8.887E-10	< 7.110E-08
SILICON	2.390E+00	1.500E+05	**NA/ND**	NO	***	1.593E-05	**NA/ND**	1.133E-06	**NA/ND**
PHOSPHORUS	< 1.000E-03	1.500E+04	5.000E-01	NO	NO	< 6.667E-08	< 2.000E-03	< 4.740E-09	< 1.422E-04
SULPHUR	9.596E+02	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
CHLORINE	1.490E+00	1.300E+06	**NA/ND**	NO	***	1.146E-06	**NA/ND**	8.149E-08	**NA/ND**
POTASSIUM	7.580E+00	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
CALCIUM(ION)	7.710E+02	2.400E+05	1.600E+04	NO	NO	3.212E-03	4.819E-02	2.284E-04	3.426E-03
TITANIUM	< 1.000E-02	9.000E+04	8.200E+02	NO	NO	< 1.111E-07	< 1.220E-05	< 7.900E-09	< 8.671E-07
VANADIUM	2.700E-02	2.500E+03	1.500E+02	NO	NO	1.080E-05	1.800E-04	7.679E-07	1.280E-05
CHROMIUM	2.400E-02	2.500E+02	2.500E+02	NO	NO	9.600E-05	9.600E-05	6.826E-06	6.826E-06
MANGANESE	< 1.000E-03	2.500E+02	1.000E+02	NO	NO	< 4.000E-06	< 1.000E-05	< 2.844E-07	< 7.110E-07
IRON	< 1.000E-03	1.500E+03	2.500E+02	NO	NO	< 6.667E-07	< 4.000E-06	< 4.740E-08	< 2.844E-07
COBALT	1.000E-03	7.500E+02	2.500E+02	NO	NO	1.333E-06	4.000E-06	9.480E-08	2.844E-07
NICKEL	1.600E-02	2.300E+02	1.000E+01	NO	NO	6.957E-05	1.600E-03	4.946E-06	1.138E-04
COPPER	< 1.000E-03	5.000E+03	5.000E+01	NO	NO	< 2.000E-07	< 2.000E-05	< 1.422E-08	< 1.422E-06
ZINC	< 1.000E-03	2.500E+04	1.000E+02	NO	NO	< 4.000E-08	< 1.000E-05	< 2.844E-09	< 7.110E-07
GALLIUM	< 1.000E-03	7.400E+04	**NA/ND**	NO	***	< 1.351E-08	< **NA/ND**	< 9.608E-10	< **NA/ND**
GERMANIUM	< 7.[illegible]00E-03	8.400E+03	**NA/ND**	NO	***	< 8.333E-07	< **NA/ND**	< 5.925E-08	< **NA/ND**
ARSENIC	[illegible]0E-02	2.500E+02	5.000E+01	NO	NO	3.440E-04	1.720E-03	2.446E-05	1.223E-04
SELENIUM	[illegible].700E-02	5.000E+01	2.500E+01	NO	NO	5.400E-04	1.080E-03	3.839E-05	7.679E-05
BROMINE	< 1.400E-02	**NA/ND**	**NA/ND**	***	***	< **NA/ND**	< **NA/ND**	< **NA/ND**	< **NA/ND**
RUBIDIUM	< 2.400E-02	1.800E+06	**NA/ND**	NO	***	< 1.333E-08	< **NA/ND**	< 9.480E-10	< **NA/ND**
STRONTIUM	2.237E+00	4.600E+04	**NA/ND**	NO	***	4.863E-05	**NA/ND**	3.458E-06	**NA/ND**
YTTRIUM	< 1.000E-03	1.500E+04	**NA/ND**	NO	***	< 6.667E-08	< **NA/ND**	< 4.740E-09	< **NA/ND**
ZIRCONIUM	< 2.000E-03	7.500E+04	**NA/ND**	NO	***	< 2.667E-08	< **NA/ND**	< 1.896E-09	< **NA/ND**
NIOBIUM	< 1.000E-03	3.300E+05	**NA/ND**	NO	***	< 3.030E-09	< **NA/ND**	< 2.155E-10	< **NA/ND**
MOLYBDENUM	< 5.600E-02	7.500E+04	7.000E+03	NO	NO	< 7.467E-07	< 8.000E-06	< 5.309E-06	< 5.688E-07
RUTHENIUM	< 5.000E-03	**NA/ND**	**NA/ND**	***	***	< **NA/ND**	< **NA/ND**	< **NA/ND**	< **NA/ND**

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 POLLUTANT        DISCHARGE          WATER DMEG              IF          DISCHARGE SEVERITY                   WEIGHTED
  SPECIES       CONCENTRATION                               DMEG                                             DISCHARGE
                                                          EXCEEDED                                           SEVERITY
                                  (HEALTH)   (ECOLOGICAL)  (H)  (E)   (HEALTH)        (ECOLOGICAL)      (HEALTH)   (ECOLOGICAL)


               (MICROGRAMS/ML)    (MICROGRAMS/ML)                                                            (LITERS/SEC.)


RHODIUM        < 1.000E-03     1.500E+01    **NA/ND**     NO   *** < 6.667E-05    < **NA/ND**     < 4.740E-06    < **NA/ND**
PALLADIUM      < 3.000E-03     **NA/ND**    **NA/ND**     ***  *** < **NA/ND**    < **NA/ND**     < **NA/ND**    < **NA/ND**
CADMIUM        < 1.000E-03     5.000E+01    1.000E+00     NO    NO < 2.000E-05    < 1.000E-03     < 1.422E-06    < 7.110E-05
INDIUM           NOT FOUND AS INPUT
TIN            < 3.000E-03     **NA/ND**    **NA/ND**     ***  *** < **NA/ND**    < **NA/ND**     < **NA/ND**    < **NA/ND**
ANTIMONY       < 1.000E-03     7.500E+03    2.000E+02     NO    NO < 1.333E-07    < 5.000E-06     < 9.480E-09    < 3.555E-07
TELLURIUM      < 3.000E-03     1.500E+03    **NA/ND**     NO   *** < 2.000E-06    < **NA/ND**     < 1.422E-07    < **NA/ND**
IODINE         < 5.000E-03     **NA/ND**    **NA/ND**     ***  *** < **NA/ND**    < **NA/ND**     < **NA/ND**    < **NA/ND**
CESIUM         < 2.000E-03     1.200E+06    **NA/ND**     NO   *** < 1.667E-09    < **NA/ND**     < 1.185E-10    < **NA/ND**
BARIUM           4.760E-01     5.000E+03    2.500E+03     NO    NO   9.520E-05      1.904E-04       6.769E-06      1.354E-05
LANTHANUM      < 1.000E-03     1.700E+06    **NA/ND**     NO   *** < 5.882E-10    < **NA/ND**     < 4.182E-11    < **NA/ND**
CERIUM         < 1.000E-03     5.500E+05    **NA/ND**     NO   *** < 1.818E-09    < **NA/ND**     < 1.293E-10    < **NA/ND**
PRASEODYMIUM   < 1.000E-03     7.700E+05    **NA/ND**     NO   *** < 1.299E-09    < **NA/ND**     < 9.234E-11    < **NA/ND**
NEODYMIUM      < 4.000E-03     **NA/ND**    **NA/ND**     ***  *** < **NA/ND**    < **NA/ND**     < **NA/ND**    < **NA/ND**
SAMARIUM       < 3.000E-03     7.900E+05    **NA/ND**     NO   *** < 3.797E-09    < **NA/ND**     < 2.700E-10    < **NA/ND**
EUROPIUM       < 1.000E-03     **NA/ND**    **NA/ND**     ***  *** < **NA/ND**    < **NA/ND**     < **NA/ND**    < **NA/ND**
GADOLINIUM     < 2.000E-03     **NA/ND**    **NA/ND**     ***  *** < **NA/ND**    < **NA/ND**     < **NA/ND**    < **NA/ND**
TERBIUM        < 1.000E-03     **NA/ND**    **NA/ND**     ***  *** < **NA/ND**    < **NA/ND**     < **NA/ND**    < **NA/ND**
DYSPROSIUM     < 2.000E-03     2.300E+05    **NA/ND**     NO   *** < 8.696E-09    < **NA/ND**     < 6.183E-10    < **NA/ND**
HOLIMIUM       < 1.000E-03     **NA/ND**    **NA/ND**     ***  *** < **NA/ND**    < **NA/ND**     < **NA/ND**    < **NA/ND**
ERBIUM         < 3.000E-03     **NA/ND**    **NA/ND**     ***  *** < **NA/ND**    < **NA/ND**     < **NA/ND**    < **NA/ND**
THULIUM        < 1.000E-03     **NA/ND**    **NA/ND**     ***  *** < **NA/ND**    < **NA/ND**     < **NA/ND**    < **NA/ND**
YTTERBIUM      < 2.000E-03     1.500E+04    **NA/ND**     NO   *** < 1.333E-07    < **NA/ND**     < 9.480E-09    < **NA/ND**
LUTETIUM       < 1.000E-03     **NA/ND**    **NA/ND**     ***  *** < **NA/ND**    < **NA/ND**     < **NA/ND**    < **NA/ND**
HAFFNIUM       < 6.000E-03     7.500E+04    **NA/ND**     NO   *** < 8.000E-08    < **NA/ND**     < 5.688E-09    < **NA/ND**
TUNGSTEN       < 4.000E-03     1.500E+04    **NA/ND**     NO   *** < 2.667E-07    < **NA/ND**     < 1.896E-08    < **NA/ND**
RHENIUM        < 4.000E-03     **NA/ND**    **NA/ND**     ***  *** < **NA/ND**    < **NA/ND**     < **NA/ND**    < **NA/ND**
OSMIUM         < 5.000E-03     **NA/ND**    **NA/ND**     ***  *** < **NA/ND**    < **NA/ND**     < **NA/ND**    < **NA/ND**
IRIDIUM        < 5.000E-03     3.000E+01    **NA/ND**     NO   *** < 1.667E-04    < **NA/ND**     < 1.185E-05    < **NA/ND**
GOLD           < 2.000E-03     **NA/ND**    **NA/ND**     ***  *** < **NA/ND**    < **NA/ND**     < **NA/ND**    < **NA/ND**
THALLIUM       < 3.000E-03     1.500E+03    **NA/ND**     NO   *** < 2.000E-06    < **NA/ND**     < 1.422E-07    < **NA/ND**
LEAD             1.700E-02     2.500E+02    5.000E+01     NO    NO   6.800E-05      3.400E-04       4.835E-06      2.417E-05
BISMUTH        < 2.000E-03     6.100E+03    **NA/ND**     NO   *** < 3.279E-07    < **NA/ND**     < 2.331E-08    < **NA/ND**
THORIUM        < 7.000E-03     6.300E+03    **NA/ND**     NO   *** < 1.111E-06    < **NA/ND**     < 7.900E-08    < **NA/ND**
URANIUM        < 5.000E-03     6.000E+04    5.000E+02     NO    NO < 8.333E-08    < 1.000E-05     < 5.925E-09    < 7.110E-07
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                    EX-01-07FA2

          SUBTOTAL INORGANIC DISCHARGE SEVERITY FROM THE EFFLUENT STREAM :


SUBTOTAL DISCHARGE SEVERITY (HEALTH DMEG BASED) =      5.462E-03
                             Ecological
SUBTOTAL DISCHARGE SEVERITY (HEALTH DMEG BASED) =      5.706E-02

          SUBTOTAL INORGANIC WEIGHTED DISCHARGE SEVERITY FROM THE EFFLUENT STREAM :


SUBTOTAL WEIGHTED DISCHARGE SEVERITY (HEALTH DMEG BASED) =      < 3.884E-04

SUBTOTAL WEIGHTED DISCHARGE SEVERITY (ECOLOGICAL DMEG BASED) =  < 4.057E-03
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                              SAM / IA ANALYSIS :    INORGANIC EMISSIONS

SAM / IA, A SOURCE ANALYSIS MODEL ,WHICH IS BASED ON A COMPARISON OF DISCHARGE CONCENTRATIONS WITH A SET OF DISCHARGE
MULTIMEDIA ENVIRONMENTAL GOALS (DMEG) CRITERIA ESTABLISHED BY THE U.S. E.P.A., IS USED FOR RAPID SCREENING OF EACH
DISCHARGE STREAM FROM FLUIDIZED BED COAL COMBUSTION PROCESS.

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                                          BACKGROUND INFORMATION

PROCESS CHARACTERISTICS     SOURCE :                        EXXON MINIPLANT WITH REGENERATION

                            BED TEMPERATURE :               894 C

                            PRESSURE :                      760 KPA

                            BED HEIGHT :                    3.10 M

                            FLUIDIZING VELOCITY :           1.46 M/S

                            COAL TYPE :                     CHAMPION

                            SORBENT TYPE :                  GROVE LIMESTONE


SAMPLING CHARACTERISTICS    TEST DATE :                     MAY 2 1979

                            TEST NUMBER :                   01

                            SAMPLING GROUP(S) :

                            STREAM SAMPLED :                EXXON THIRD CYCLONE

                            SAMPLING TECHNIQUE :            GRAB SAMPLES


STREAM CHARACTERISTICS      STREAM ANALYZED :               EX-01-08-FA3

                            SAMPLE TYPE :                   ASTM-A LEACHATE

                            ANALYTICAL TECHNIQUE :           SSMS/AAS

                            STREAM FLOW RATE :              1.420E-02     (   LITERS / SEC. )

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EX-01-08-FAS

N.B. POLLUTANT CONCENTRATIONS ARE QUOTED IN PARTS PER MILLION BY WEIGHT, THESE HAVE BEEN CONVERTED TO MICROGRAMS PER MILLILITER

(**NA/ND** DENOTES DATA NOT AVAILBLE OR NOT DETERMINED)

POLLUTANT SPECIES	DISCHARGE CONCENTRATION	WATER DMEG		IF DMEG EXCEEDED		DISCHARGE SEVERITY		WEIGHTED DISCHARGE SEVERITY	
		(HEALTH)	(ECOLOGICAL)	(H)	(E)	(HEALTH)	(ECOLOGICAL)	(HEALTH)	(ECOLOGICAL)
	(MICROGRAMS/ML)	(MICROGRAMS/ML)						(LITERS/SEC.)	
LITHIUM	2.500E-02	3.300E+02	3.800E+02	NO	NO	7.576E-05	6.579E-05	1.076E-06	9.342E-07
BERYLLIUM	< 1.000E-03	3.000E+01	5.500E+01	NO	NO	< 3.333E-05	< 1.818E-05	< 4.733E-07	< 2.582E-07
BORON	3.000E-01	4.700E+04	2.500E+04	NO	NO	6.383E-06	1.200E-05	9.064E-08	1.704E-07
FLUORINE	7.600E-02	3.800E+04	**NA/ND**	NO	***	2.000E-06	**NA/ND**	2.840E-08	**NA/ND**
SODIUM	8.390E+00	8.000E+05	**NA/ND**	NO	***	1.049E-05	**NA/ND**	1.489E-07	**NA/ND**
MAGNESIUM	5.870E-01	9.000E+04	8.700E+04	NO	NO	6.522E-06	6.747E-06	9.262E-08	9.581E-08
ALUMINIUM	2.835E+00	8.000E+04	1.000E+03	NO	NO	3.544E-05	2.835E-03	5.032E-07	4.026E-05
SILICON	2.310E+00	1.500E+05	**NA/ND**	NO	***	1.540E-05	**NA/ND**	2.187E-07	**NA/ND**
PHOSPHORUS	< 1.000E-02	1.500E+04	5.000E-01	NO	NO	< 6.667E-07	< 2.000E-02	< 9.467E-09	< 2.840E-04
SULPHUR	6.696E+02	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
CHLORINE	6.300E-02	1.300E+06	**NA/ND**	NO	***	4.846E-08	**NA/ND**	6.882E-10	**NA/ND**
POTASSIUM	1.090E+01	**NA/ND**	**NA/ND**	***	***	**NA/ND**	**NA/ND**	**NA/ND**	**NA/ND**
CALCIUM(ION)	6.400E+02	2.400E+05	1.600E+04	NO	NO	2.667E-03	4.000E-02	3.787E-05	5.680E-04
TITANIUM	6.000E-03	9.000E+04	8.200E+02	NO	NO	6.667E-08	7.317E-06	9.467E-10	1.039E-07
VANADIUM	3.100E-01	2.500E+03	1.500E+02	NO	NO	1.240E-04	2.067E-03	1.761E-06	2.935E-05
CHROMIUM	2.600E-02	2.500E+02	2.500E+02	NO	NO	1.040E-04	1.040E-04	1.477E-06	1.477E-06
MANGANESE	2.000E-03	2.500E+02	1.000E+02	NO	NO	8.000E-06	2.000E-05	1.136E-07	2.840E-07
IRON	< 1.000E-03	1.500E+03	2.500E+02	NO	NO	< 6.667E-07	< 4.000E-06	< 9.467E-09	< 5.680E-08
COBALT	1.000E-03	7.500E+02	2.500E+02	NO	NO	1.333E-06	4.000E-06	1.893E-08	5.680E-08
NICKEL	1.000E-03	2.300E+02	1.000E+01	NO	NO	4.348E-06	1.000E-04	6.174E-08	1.420E-06
COPPER	< 1.000E-03	5.000E+03	5.000E+01	NO	NO	< 2.000E-07	< 2.000E-05	< 2.840E-09	< 2.840E-07
ZINC	< 6.000E-03	2.500E+04	1.000E+02	NO	NO	< 2.400E-07	< 6.000E-05	< 3.408E-09	< 8.520E-07
GALLIUM	< 2.200E-02	7.400E+04	**NA/ND**	NO	***	< 2.973E-07	< **NA/ND**	< 4.222E-09	< **NA/ND**
GERMANIUM	< 1.900E-02	8.400E+03	**NA/ND**	NO	***	< 2.262E-06	< **NA/ND**	< 3.212E-08	< **NA/ND**
ARSENIC	1.260E-01	2.500E+02	5.000E+01	NO	NO	5.040E-04	2.520E-03	7.157E-06	3.578E-05
SELENIUM	3.700E-02	5.000E+01	2.500E+01	NO	NO	7.400E-04	1.480E-03	1.051E-05	2.102E-05
BROMINE	< 5.000E-02	**NA/ND**	**NA/ND**	***	***	< **NA/ND**	< **NA/ND**	< **NA/ND**	< **NA/ND**
RUBIDIUM	< 4.300E-02	1.800E+06	**NA/ND**	NO	***	< 2.389E-08	< **NA/ND**	< 3.392E-10	< **NA/ND**
STRONTIUM	8.897E+00	4.600E+04	**NA/ND**	NO	***	1.934E-04	**NA/ND**	2.746E-06	**NA/ND**
YTTRIUM	< 1.000E-03	1.500E+04	**NA/ND**	NO	***	< 6.667E-08	< **NA/ND**	< 9.467E-10	< **NA/ND**
ZIRCONIUM	< 1.000E-03	7.500E+04	**NA/ND**	NO	***	< 1.333E-08	< **NA/ND**	< 1.893E-10	< **NA/ND**
NIOBIUM	< 1.000E-03	3.300E+05	**NA/ND**	NO	***	< 3.030E-09	< **NA/ND**	< 4.303E-11	< **NA/ND**
MOLYBDENUM	< 1.200E-01	7.500E+04	7.000E+03	NO	NO	< 1.600E-06	< 1.714E-05	< 2.272E-08	< 2.434E-07
RUTHENIUM	< 2.000E-03	**NA/ND**	**NA/ND**	***	***	< **NA/ND**	< **NA/ND**	< **NA/ND**	< **NA/ND**

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POLLUTANT       DISCHARGE          WATER DMEG              IF        DISCHARGE SEVERITY              WEIGHTED
SPECIES        CONCENTRATION                              DMEG                                       DISCHARGE
                                                        EXCEEDED                                     SEVERITY
                               (HEALTH)   (ECOLOGICAL)  (H)  (E)   (HEALTH)      (ECOLOGICAL)     (HEALTH)   (ECOLOGICAL)


               (MICROGRAMS/ML)     (MICROGRAMS/ML)                                                   (LITERS/SEC.)


RHODIUM        < 1.000E-03   1.500E+01    **NA/ND**    NO   *** < 6.667E-05    < **NA/ND**    < 9.467E-07    < **NA/ND**
PALLADIUM      < 1.000E-03   **NA/ND**    **NA/ND**    ***  *** < **NA/ND**    < **NA/ND**    < **NA/ND**    < **NA/ND**
CADMIUM        < 1.000E-03   5.000E+01    1.000E+00    NO    NO < 2.000E-05    < 1.000E-03    < 2.840E-07    < 1.420E-05
INDIUM           NOT FOUND AS INPUT
TIN            < 1.000E-03   **NA/ND**    **NA/ND**    ***  *** < **NA/ND**    < **NA/ND**    < **NA/ND**    < **NA/ND**
ANTIMONY       < 1.000E-03   7.500E+03    2.000E+02    NO    NO < 1.333E-07    < 5.000E-06    < 1.893E-09    < 7.100E-08
TELLURIUM      < 2.000E-03   1.500E+03    **NA/ND**    NO   *** < 1.333E-06    < **NA/ND**    < 1.893E-08    < **NA/ND**
IODINE         < 2.000E-03   **NA/ND**    **NA/ND**    ***  *** < **NA/ND**    < **NA/ND**    < **NA/ND**    < **NA/ND**
CESIUM         < 1.000E-03   1.200E+06    **NA/ND**    NO   *** < 8.333E-10    < **NA/ND**    < 1.183E-11    < **NA/ND**
BARIUM           2.260E-01   5.000E+03    2.500E+03    NO    NO   4.520E-05      9.040E-05      6.418E-07      1.284E-06
LANTHANUM      < 1.000E-03   1.700E+06    **NA/ND**    NO   *** < 5.882E-10    < **NA/ND**    < 8.353E-12    < **NA/ND**
CERIUM         < 1.000E-03   5.500E+05    **NA/ND**    NO   *** < 1.818E-09    < **NA/ND**    < 2.582E-11    < **NA/ND**
PRASEODYMIUM   < 1.000E-03   7.700E+05    **NA/ND**    NO   *** < 1.299E-09    < **NA/ND**    < 1.844E-11    < **NA/ND**
NEODYMIUM      < 2.000E-03   **NA/ND**    **NA/ND**    ***  *** < **NA/ND**    < **NA/ND**    < **NA/ND**    < **NA/ND**
SAMARIUM       < 2.000E-03   7.900E+05    **NA/ND**    NO   *** < 2.532E-09    < **NA/ND**    < 3.595E-11    < **NA/ND**
EUROPIUM       < 1.000E-03   **NA/ND**    **NA/ND**    ***  *** < **NA/ND**    < **NA/ND**    < **NA/ND**    < **NA/ND**
GADOLINIUM     < 1.000E-03   **NA/ND**    **NA/ND**    ***  *** < **NA/ND**    < **NA/ND**    < **NA/ND**    < **NA/ND**
TERBIUM        < 1.000E-03   **NA/ND**    **NA/ND**    ***  *** < **NA/ND**    < **NA/ND**    < **NA/ND**    < **NA/ND**
DYSPROSIUM     < 1.000E-03   2.300E+05    **NA/ND**    NO   *** < 4.348E-09    < **NA/ND**    < 6.174E-11    < **NA/ND**
HOLIMIUM       < 1.000E-03   **NA/ND**    **NA/ND**    ***  *** < **NA/ND**    < **NA/ND**    < **NA/ND**    < **NA/ND**
ERBIUM         < 2.000E-03   **NA/ND**    **NA/ND**    ***  *** < **NA/ND**    < **NA/ND**    < **NA/ND**    < **NA/ND**
THULIUM        < 1.000E-03   **NA/ND**    **NA/ND**    ***  *** < **NA/ND**    < **NA/ND**    < **NA/ND**    < **NA/ND**
YTTERBIUM      < 1.000E-03   1.500E+04    **NA/ND**    NO   *** < 6.667E-08    < **NA/ND**    < 9.467E-10    < **NA/ND**
LUTETIUM       < 1.000E-03   **NA/ND**    **NA/ND**    ***  *** < **NA/ND**    < **NA/ND**    < **NA/ND**    < **NA/ND**
HAFFNIUM       < 3.000E-03   7.500E+04    **NA/ND**    NO   *** < 4.000E-08    < **NA/ND**    < 5.680E-10    < **NA/ND**
TUNGSTEN       < 3.000E-03   1.500E+04    **NA/ND**    NO   *** < 2.000E-07    < **NA/ND**    < 2.840E-09    < **NA/ND**
RHENIUM        < 2.000E-03   **NA/ND**    **NA/ND**    ***  *** < **NA/ND**    < **NA/ND**    < **NA/ND**    < **NA/ND**
OSMIUM         < 3.000E-03   **NA/ND**    **NA/ND**    ***  *** < **NA/ND**    < **NA/ND**    < **NA/ND**    < **NA/ND**
IRIDIUM        < 5.000E-03   5.000E+01    **NA/ND**    NO   *** < 1.000E-04    < **NA/ND**    < 1.420E-06    < **NA/ND**
GOLD           < 2.000E-03   **NA/ND**    **NA/ND**    ***  *** < **NA/ND**    < **NA/ND**    < **NA/ND**    < **NA/ND**
THALLIUM       < 1.000E-03   1.500E+03    **NA/ND**    NO   *** < 6.667E-07    < **NA/ND**    < 9.467E-09    < **NA/ND**
LEAD             1.900E-02   2.500E+02    5.000E+01    NO    NO   7.600E-05      3.800E-04      1.079E-06      5.396E-06
BISMUTH        < 1.000E-03   6.100E+03    **NA/ND**    NO   *** < 1.639E-07    < **NA/ND**    < 2.328E-09    < **NA/ND**
THORIUM        < 3.000E-03   6.300E+03    **NA/ND**    NO   *** < 4.762E-07    < **NA/ND**    < 6.762E-09    < **NA/ND**
URANIUM        < 2.000E-03   6.000E+04    5.000E+02    NO    NO < 3.333E-08    < 4.000E-06    < 4.733E-10    < 5.680E-08
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                     EX-01-08-FAS

             SUBTOTAL INORGANIC DISCHARGE SEVERITY FROM THE EFFLUENT STREAM :


SUBTOTAL DISCHARGE SEVERITY (HEALTH DMEG BASED) =       4.848E-03
                             Ecological
SUBTOTAL DISCHARGE SEVERITY (HEALTH DMEG BASED) =       7.082E-02

             SUBTOTAL INORGANIC WEIGHTED DISCHARGE SEVERITY FROM THE EFFLUENT STREAM :


SUBTOTAL WEIGHTED DISCHARGE SEVERITY (HEALTH DMEG BASED) =      < 6.884E-05
SUBTOTAL WEIGHTED DISCHARGE SEVERITY (ECOLOGICAL DMEG BASED) =  < 1.006E-03
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                         SAM / IA ANALYSIS :    INORGANIC EMISSIONS

   SAM / IA, A SOURCE ANALYSIS MODEL ,WHICH IS BASED ON A COMPARISON OF DISCHARGE CONCENTRATIONS WITH A SET OF DISCHARGE
   MULTIMEDIA ENVIRONMENTAL GOALS (DMEG) CRITERIA ESTABLISHED BY THE U.S. E.P.A., IS USED FOR RAPID SCREENING OF EACH
   DISCHARGE STREAM FROM FLUIDIZED BED COAL COMBUSTION PROCESS.

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                                          BACKGROUND INFORMATION

   PROCESS CHARACTERISTICS     SOURCE :                        EXXON MINIPLANT WITH REGENERATION

                               BED TEMPERATURE :               894 C

                               PRESSURE :                      760 KPA

                               BED HEIGHT :                    5.10 M

                               FLUIDIZING VELOCITY :           1.46 M/S

                               COAL TYPE :                     CHAMPION

                               SORBENT TYPE :                  GROVE LIMESTONE


   SAMPLING CHARACTERISTICS    TEST DATE :                     MAY 2 1979

                               TEST NUMBER :                   01

                               SAMPLING GROUP(S) :

                               STREAM SAMPLED :                EXXON COAL FEED

                               SAMPLING TECHNIQUE :            GRAB SAMPLES


   STREAM CHARACTERISTICS      STREAM ANALYZED :               EX1-01-09-CF

                               SAMPLE TYPE :                   ASTM-A LEACHATE

                               ANALYTICAL TECHNIQUE :            SSMS/AAS

                               STREAM FLOW RATE :              4.855E-01     (   LITERS / SEC. )

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                              EXI-01-09-CF

          N.B.  POLLUTANT CONCENTRATIONS ARE QUOTED IN PARTS PER MILLION BY WEIGHT. THESE HAVE BEEN CONVERTED
                TO MICROGRAMS PER MILLILITER


                        ( **NA/ND** DENOTES DATA NOT AVAILBLE OR NOT DETERMINED )

 POLLUTANT      DISCHARGE          WATER DMEG              IF         DISCHARGE SEVERITY             WEIGHTED
  SPECIES     CONCENTRATION                               DMEG                                       DISCHARGE
                                                        EXCEEDED                                     SEVERITY
                              (HEALTH)   (ECOLOGICAL)   (H)  (E)   (HEALTH)     (ECOLOGICAL)    (HEALTH)   (ECOLOGICAL)


              (MICROGRAMS/ML)     (MICROGRAMS/ML)                                                 (LITERS/SEC.)


 LITHIUM          9.000E-03   3.500E+02   3.800E+02   NO   NO   2.727E-05     2.368E-05     1.324E-05    1.150E-05
 BERYLLIUM      < 1.000E-03   5.000E+01   5.500E+01   NO   NO < 3.333E-05   < 1.818E-05   < 1.618E-05  < 8.827E-06
 BORON            1.900E-02   4.700E+04   2.500E+04   NO   NO   4.043E-07     7.600E-07     1.965E-07    3.690E-07
 FLUORINE         5.220E-01   3.800E+04   **NA/ND**   NO  ***   1.374E-05     **NA/ND**     6.669E-06    **NA/ND**
 SODIUM           4.390E+00   8.000E+05   **NA/ND**   NO  ***   5.487E-06     **NA/ND**     2.664E-06    **NA/ND**
 MAGNESIUM        2.370E+00   9.000E+04   8.700E+04   NO   NO   2.633E-05     2.724E-05     1.278E-05    1.323E-05
 ALUMINIUM        3.500E-02   8.000E+04   1.000E+03   NO   NO   4.375E-07     3.500E-05     2.124E-07    1.699E-05
 SILICON          8.100E-01   1.500E+05   **NA/ND**   NO  ***   5.400E-06     **NA/ND**     2.622E-06    **NA/ND**
 PHOSPHORUS     < 1.000E-03   1.500E+04   5.000E-01   NO   NO < 6.667E-08   < 2.000E-03   < 3.237E-08  < 9.710E-04
 SULPHUR          4.996E+02   **NA/ND**   **NA/ND**  ***  ***   **NA/ND**     **NA/ND**     **NA/ND**    **NA/ND**
 CHLORINE         1.410E+00   1.300E+06   **NA/ND**   NO  ***   1.085E-06     **NA/ND**     5.266E-07    **NA/ND**
 POTASSIUM        1.800E-01   **NA/ND**   **NA/ND**  ***  ***   **NA/ND**     **NA/ND**     **NA/ND**    **NA/ND**
 CALCIUM(ION)     4.750E+01   2.400E+05   1.600E+04   NO   NO   1.979E-04     2.969E-03     9.609E-05    1.441E-03
 TITANIUM       < 1.000E-03   9.000E+04   8.200E+02   NO   NO < 1.111E-08   < 1.220E-06   < 5.394E-09  < 5.921E-07
 VANADIUM       < 1.000E-03   2.500E+03   1.500E+02   NO   NO < 4.000E-07   < 6.667E-06   < 1.942E-07  < 3.237E-06
 CHROMIUM         5.000E-03   2.500E+02   2.500E+02   NO   NO   2.000E-05     2.000E-05     9.710E-06    9.710E-06
 MANGANESE      < 1.000E-03   2.500E+02   1.000E+02   NO   NO < 4.000E-06   < 1.000E-05   < 1.942E-06  < 4.855E-06
 IRON             6.989E+01   1.500E+03   2.500E+02   NO   NO   4.659E-02     2.796E-01     2.262E-02    1.357E-01
 COBALT           1.900E-01   7.500E+02   2.500E+02   NO   NO   2.533E-04     7.600E-04     1.230E-04    3.690E-04
 NICKEL           3.880E-01   2.300E+02   1.000E+01   NO   NO   1.687E-03     3.880E-02     8.190E-04    1.884E-02
 COPPER           4.900E-02   5.000E+03   5.000E+01   NO   NO   9.800E-06     9.800E-04     4.758E-06    4.758E-04
 ZINC             3.630E-01   2.500E+04   1.000E+02   NO   NO   1.452E-05     3.630E-03     7.049E-06    1.762E-03
 GALLIUM        < 1.000E-03   7.400E+04   **NA/ND**   NO  *** < 1.351E-08   < **NA/ND**   < 6.561E-09  < **NA/ND**
 GERMANIUM      < 1.000E-03   8.400E+03   **NA/ND**   NO  *** < 1.190E-07   < **NA/ND**   < 5.780E-08  < **NA/ND**
 ARSENIC          4.900E-02   2.500E+02   5.000E+01   NO   NO   1.960E-04     9.800E-04     9.516E-05    4.758E-04
 SELENIUM         1.100E-02   5.000E+01   2.500E+01   NO   NO   2.200E-04     4.400E-04     1.068E-04    2.136E-04
 BROMINE        < 2.800E-02   **NA/ND**   **NA/ND**  ***  *** < **NA/ND**   < **NA/ND**   < **NA/ND**  < **NA/ND**
 RUBIDIUM       < 1.000E-03   1.800E+06   **NA/ND**   NO  *** < 5.556E-10   < **NA/ND**   < 2.697E-10  < **NA/ND**
 STRONTIUM        5.570E-01   4.600E+04   **NA/ND**   NO  ***   1.211E-05     **NA/ND**     5.879E-06    **NA/ND**
 YTTRIUM        < 9.000E-03   1.500E+04   **NA/ND**   NO  *** < 6.000E-07   < **NA/ND**   < 2.913E-07  < **NA/ND**
 ZIRCONIUM      < 1.000E-03   7.500E+04   **NA/ND**   NO  *** < 1.333E-08   < **NA/ND**   < 6.473E-09  < **NA/ND**
 NIOBIUM        < 1.000E-03   3.300E+05   **NA/ND**   NO  *** < 3.030E-09   < **NA/ND**   < 1.471E-09  < **NA/ND**
 MOLYBDENUM     < 2.000E-03   7.500E+04   7.000E+03   NO   NO < 2.667E-08   < 2.857E-07   < 1.295E-08  < 1.387E-07
 RUTHENIUM      < 2.000E-03   **NA/ND**   **NA/ND**  ***  *** < **NA/ND**   < **NA/ND**   < **NA/ND**  < **NA/ND**
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POLLUTANT       DISCHARGE          WATER DMEG             IF          DISCHARGE SEVERITY                  WEIGHTED
 SPECIES      CONCENTRATION                              DMEG                                            DISCHARGE
                                                       EXCEEDED                                          SEVERITY
                              (HEALTH)   (ECOLOGICAL)  (H)  (E)   (HEALTH)       (ECOLOGICAL)     (HEALTH)   (ECOLOGICAL)


             (MICROGRAMS/ML)      (MICROGRAMS/ML)                                                          (LITERS/SEC.)


RHODIUM        < 1.000E-03   1.500E+01    **NA/ND**    NO   *** < 6.667E-05    < **NA/ND**    < 3.237E-05    < **NA/ND**
PALLADIUM      < 1.000E-03   **NA/ND**    **NA/ND**    ***  *** < **NA/ND**    < **NA/ND**    < **NA/ND**    < **NA/ND**
CADMIUM          1.800E-02   5.000E+01    1.000E+00    NO    NO   3.600E-04      1.800E-02      1.748E-04      8.739E-03
INDIUM          NOT FOUND AS INPUT
TIN            < 1.000E-03   **NA/ND**    **NA/ND**    ***  *** < **NA/ND**    < **NA/ND**    < **NA/ND**    < **NA/ND**
ANTIMONY       < 1.000E-03   7.500E+03    2.000E+02    NO    NO < 1.333E-07    < 5.000E-06    < 6.473E-08    < 2.427E-06
TELLURIUM      < 1.000E-03   1.500E+03    **NA/ND**    NO   *** < 6.667E-07    < **NA/ND**    < 3.237E-07    < **NA/ND**
IODINE         < 2.000E-03   **NA/ND**    **NA/ND**    ***  *** < **NA/ND**    < **NA/ND**    < **NA/ND**    < **NA/ND**
CESIUM         < 1.000E-03   1.200E+06    **NA/ND**    NO   *** < 8.333E-10    < **NA/ND**    < 4.046E-10    < **NA/ND**
BARIUM           9.300E-02   5.000E+03    2.500E+03    NO    NO   1.860E-05      3.720E-05      9.030E-06      1.806E-05
LANTHANUM      < 2.000E-03   1.700E+06    **NA/ND**    NO   *** < 1.176E-09    < **NA/ND**    < 5.712E-10    < **NA/ND**
CERIUM         < 6.000E-03   5.500E+05    **NA/ND**    NO   *** < 1.091E-08    < **NA/ND**    < 5.296E-09    < **NA/ND**
PRASEODYMIUM   < 1.000E-03   7.700E+05    **NA/ND**    NO   *** < 1.299E-09    < **NA/ND**    < 6.305E-10    < **NA/ND**
NEODYMIUM      < 2.000E-03   **NA/ND**    **NA/ND**    ***  *** < **NA/ND**    < **NA/ND**    < **NA/ND**    < **NA/ND**
SAMARIUM       < 2.000E-03   7.900E+05    **NA/ND**    NO   *** < 2.532E-09    < **NA/ND**    < 1.229E-09    < **NA/ND**
EUROPIUM       < 1.000E-03   **NA/ND**    **NA/ND**    ***  *** < **NA/ND**    < **NA/ND**    < **NA/ND**    < **NA/ND**
GADOLINIUM     < 1.000E-03   **NA/ND**    **NA/ND**    ***  *** < **NA/ND**    < **NA/ND**    < **NA/ND**    < **NA/ND**
TERBIUM        < 1.000E-03   **NA/ND**    **NA/ND**    ***  *** < **NA/ND**    < **NA/ND**    < **NA/ND**    < **NA/ND**
DYSPROSIUM     < 2.000E-03   2.300E+05    **NA/ND**    NO   *** < 8.696E-09    < **NA/ND**    < 4.222E-09    < **NA/ND**
HOLIMIUM       < 1.000E-03   **NA/ND**    **NA/ND**    ***  *** < **NA/ND**    < **NA/ND**    < **NA/ND**    < **NA/ND**
ERBIUM         < 2.000E-03   **NA/ND**    **NA/ND**    ***  *** < **NA/ND**    < **NA/ND**    < **NA/ND**    < **NA/ND**
THULIUM        < 1.000E-03   **NA/ND**    **NA/ND**    ***  *** < **NA/ND**    < **NA/ND**    < **NA/ND**    < **NA/ND**
YTTERBIUM      < 1.000E-03   1.500E+04    **NA/ND**    NO   *** < 6.667E-08    < **NA/ND**    < 3.237E-08    < **NA/ND**
LUTETIUM       < 1.000E-03   **NA/ND**    **NA/ND**    ***  *** < **NA/ND**    < **NA/ND**    < **NA/ND**    < **NA/ND**
HAFFNIUM       < 3.000E-03   7.500E+04    **NA/ND**    NO   *** < 4.000E-08    < **NA/ND**    < 1.942E-08    < **NA/ND**
TUNGSTEN       < 3.000E-03   1.500E+04    **NA/ND**    NO   *** < 2.000E-07    < **NA/ND**    < 9.710E-08    < **NA/ND**
RHENIUM        < 2.000E-03   **NA/ND**    **NA/ND**    ***  *** < **NA/ND**    < **NA/ND**    < **NA/ND**    < **NA/ND**
OSMIUM         < 3.000E-03   **NA/ND**    **NA/ND**    ***  *** < **NA/ND**    < **NA/ND**    < **NA/ND**    < **NA/ND**
IRIDIUM        < 3.000E-03   3.000E+01    **NA/ND**    NO   *** < 1.000E-04    < **NA/ND**    < 4.855E-05    < **NA/ND**
GOLD           < 2.000E-03   **NA/ND**    **NA/ND**    ***  *** < **NA/ND**    < **NA/ND**    < **NA/ND**    < **NA/ND**
THALLIUM       < 1.000E-03   1.500E+03    **NA/ND**    NO   *** < 6.667E-07    < **NA/ND**    < 3.237E-07    < **NA/ND**
LEAD             9.000E-03   2.500E+02    5.000E+01    NO    NO   3.600E-05      1.800E-04      1.748E-05      8.739E-05
BISMUTH        < 1.000E-03   6.100E+03    **NA/ND**    NO   *** < 1.639E-07    < **NA/ND**    < 7.959E-08    < **NA/ND**
THORIUM        < 3.000E-03   6.300E+03    **NA/ND**    NO   *** < 4.762E-07    < **NA/ND**    < 2.312E-07    < **NA/ND**
URANIUM        < 2.000E-03   6.000E+04    5.000E+02    NO    NO < 3.333E-08    < 4.000E-06    < 1.618E-08    < 1.942E-06
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                         EXI-01-09-CP

          SUBTOTAL INORGANIC DISCHARGE SEVERITY FROM THE EFFLUENT STREAM :


SUBTOTAL DISCHARGE SEVERITY (HEALTH DMEG BASED) =       4.991E-02
                             Ecological
SUBTOTAL DISCHARGE SEVERITY (HEALTH DMEG BASED) =       3.485E-01

          SUBTOTAL INORGANIC WEIGHTED DISCHARGE SEVERITY FROM THE EFFLUENT STREAM :


SUBTOTAL WEIGHTED DISCHARGE SEVERITY (HEALTH DMEG BASED) =       < 2.423E-02
SUBTOTAL WEIGHTED DISCHARGE SEVERITY (ECOLOGICAL DMEG BASED) =  < 1.692E-01
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                              SAM / IA ANALYSIS :    INORGANIC EMISSIONS

   SAM / IA, A SOURCE ANALYSIS MODEL ,WHICH IS BASED ON A COMPARISON OF DISCHARGE CONCENTRATIONS WITH A SET OF DISCHARGE
   MULTIMEDIA ENVIRONMENTAL GOALS (DMEG) CRITERIA ESTABLISHED BY THE U.S. E.P.A., IS USED FOR RAPID SCREENING OF EACH
   DISCHARGE STREAM FROM FLUIDIZED BED COAL COMBUSTION PROCESS.

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                                         BACKGROUND INFORMATION

   PROCESS CHARACTERISTICS     SOURCE :                        EXXON MINIPLANT WITH REGENERATION

                               BED TEMPERATURE :               894 C

                               PRESSURE :                      760 KPA

                               BED HEIGHT :                    3.10 M

                               FLUIDIZING VELOCITY :           1.46 M/S

                               COAL TYPE :                     CHAMPION

                               SORBENT TYPE :                  GROVE LIMESTONE

   SAMPLING CHARACTERISTICS    TEST DATE :                     MAY 2 1979

                               TEST NUMBER :                   01

                               SAMPLING GROUP(S) :

                               STREAM SAMPLED :                EXXON SORBENT FEED

                               SAMPLING TECHNIQUE :            GRAB SAMPLES

   STREAM CHARACTERISTICS      STREAM ANALYZED :               EXI-01-10-SF

                               SAMPLE TYPE :                   ASTM-A LEACHATE

                               ANALYTICAL TECHNIQUE :           SSMS/AAS

                               STREAM FLOW RATE :              7.750E-02     (   LITERS / SEC. )

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                                             EX1-01-10-SF

             N.B.  POLLUTANT CONCENTRATIONS ARE QUOTED IN PARTS PER MILLION BY WEIGHT. THESE HAVE BEEN CONVERTED
                   TO MICROGRAMS PER MILLILITER



                           ( **NA/ND** DENOTES DATA NOT AVAILBLE OR NOT DETERMINED )

 POLLUTANT        DISCHARGE           WATER DMEG              IF          DISCHARGE SEVERITY              WEIGHTED
  SPECIES       CONCENTRATION                                DMEG                                         DISCHARGE
                                                           EXCEEDED                                       SEVERITY
                                  (HEALTH)   (ECOLOGICAL)  (H)  (E)   (HEALTH)      (ECOLOGICAL)    (HEALTH)  (ECOLOGICAL)


               (MICROGRAMS/ML)      (MICROGRAMS/ML)                                                       (LITERS/SEC.)


LITHIUM           1.000E-03     3.300E+02    3.800E+02    NO   NO     3.030E-06      2.632E-06      2.348E-07     2.039E-07
BERYLLIUM       < 1.000E-03     3.000E+01    5.500E+01    NO   NO < 3.333E-05    < 1.818E-05    < 2.583E-06   < 1.409E-06
BORON             1.000E-03     4.700E+04    2.500E+04    NO   NO     2.128E-08      4.000E-08      1.649E-09     3.100E-09
FLUORINE          3.720E-01     3.800E+04    **NA/ND**    NO  ***     9.789E-06      **NA/ND**      7.587E-07     **NA/ND**
SODIUM            5.000E-02     8.000E+05    **NA/ND**    NO  ***     6.250E-08      **NA/ND**      4.844E-09     **NA/ND**
MAGNESIUM         5.870E-01     9.000E+04    8.700E+04    NO   NO     6.522E-06      6.747E-06      5.055E-07     5.229E-07
ALUMINIUM         2.850E-01     8.000E+04    1.000E+03    NO   NO     3.562E-06      2.850E-04      2.761E-07     2.209E-05
SILICON         < 1.000E-03     1.500E+05    **NA/ND**    NO  *** < 6.667E-09    < **NA/ND**    < 5.167E-10   < **NA/ND**
PHOSPHORUS      < 1.000E-03     1.500E+04    5.000E-01    NO   NO < 6.667E-08    < 2.000E-03    < 5.167E-09   < 1.550E-04
SULPHUR           3.450E+00     **NA/ND**    **NA/ND**   ***  ***     **NA/ND**      **NA/ND**      **NA/ND**     **NA/ND**
CHLORINE        < 1.000E-03     1.300E+06    **NA/ND**    NO  *** < 7.692E-10    < **NA/ND**    < 5.962E-11   < **NA/ND**
POTASSIUM         3.000E-02     **NA/ND**    **NA/ND**   ***  ***     **NA/ND**      **NA/ND**      **NA/ND**     **NA/ND**
CALCIUM(ION)      8.500E+00     2.400E+05    1.600E+04    NO   NO     3.542E-05      5.312E-04      2.745E-06     4.117E-05
TITANIUM        < 1.000E-03     9.000E+04    8.200E+02    NO   NO < 1.111E-08    < 1.220E-06    < 8.611E-10   < 9.451E-08
VANADIUM        < 1.000E-03     2.500E+03    1.500E+02    NO   NO < 4.000E-07    < 6.667E-06    < 3.100E-08   < 5.167E-07
CHROMIUM        < 1.000E-03     2.500E+02    2.500E+02    NO   NO < 4.000E-06    < 4.000E-06    < 3.100E-07   < 3.100E-07
MANGANESE       < 1.000E-03     2.500E+02    1.000E+02    NO   NO < 4.000E-06    < 1.000E-05    < 3.100E-07   < 7.750E-07
IRON            < 1.000E-03     1.500E+03    2.500E+02    NO   NO < 6.667E-07    < 4.000E-06    < 5.167E-08   < 3.100E-07
COBALT          < 1.000E-03     7.500E+02    2.500E+02    NO   NO < 1.333E-06    < 4.000E-06    < 1.033E-07   < 3.100E-07
NICKEL          < 1.000E-03     2.300E+02    1.000E+01    NO   NO < 4.348E-06    < 1.000E-04    < 3.370E-07   < 7.750E-06
COPPER          < 1.000E-03     5.000E+03    5.000E+01    NO   NO < 2.000E-07    < 2.000E-05    < 1.550E-08   < 1.550E-06
ZINC              1.900E-02     2.500E+04    1.000E+02    NO   NO     7.600E-07      1.900E-04      5.890E-08     1.472E-05
GALLIUM         < 1.000E-03     7.400E+04    **NA/ND**    NO  *** < 1.351E-08    < **NA/ND**    < 1.047E-09   < **NA/ND**
GERMANIUM       < 1.000E-03     8.400E+03    **NA/ND**    NO  *** < 1.190E-07    < **NA/ND**    < 9.226E-09   < **NA/ND**
ARSENIC           7.000E-03     2.500E+02    5.000E+01    NO   NO     2.800E-05      1.400E-04      2.170E-06     1.085E-05
SELENIUM        < 5.000E-03     5.000E+01    2.500E+01    NO   NO < 1.000E-04    < 2.000E-04    < 7.750E-06   < 1.550E-05
BROMINE           7.000E-03     **NA/ND**    **NA/ND**   ***  ***     **NA/ND**      **NA/ND**      **NA/ND**     **NA/ND**
RUBIDIUM        < 1.000E-03     1.800E+06    **NA/ND**    NO  *** < 5.556E-10    < **NA/ND**    < 4.306E-11   < **NA/ND**
STRONTIUM         6.100E-02     4.600E+04    **NA/ND**    NO  ***     1.326E-06      **NA/ND**      1.028E-07     **NA/ND**
YTTRIUM         < 1.000E-03     1.500E+04    **NA/ND**    NO  *** < 6.667E-08    < **NA/ND**    < 5.167E-09   < **NA/ND**
ZIRCONIUM       < 1.000E-03     7.500E+04    **NA/ND**    NO  *** < 1.333E-08    < **NA/ND**    < 1.033E-09   < **NA/ND**
NIOBIUM         < 1.000E-03     3.300E+05    **NA/ND**    NO  *** < 3.030E-09    < **NA/ND**    < 2.348E-10   < **NA/ND**
MOLYBDENUM        1.000E-03     7.500E+04    7.000E+03    NO   NO     1.333E-08      1.429E-07      1.033E-09     1.107E-08
RUTHENIUM       < 2.000E-03     **NA/ND**    **NA/ND**   ***  *** < **NA/ND**    < **NA/ND**    < **NA/ND**   < **NA/ND**
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POLLUTANT        DISCHARGE        WATER DMEG            IF         DISCHARGE SEVERITY               WEIGHTED
 SPECIES       CONCENTRATION                           DMEG                                         DISCHARGE
                                                     EXCEEDED                                       SEVERITY
                              (HEALTH)  (ECOLOGICAL)  (H)  (E)  (HEALTH)      (ECOLOGICAL)    (HEALTH)  (ECOLOGICAL)


               (MICROGRAMS/ML)   (MICROGRAMS/ML)                                                   (LITERS/SEC.)


RHODIUM       < 1.000E-03   1.500E+01   **NA/ND**    NO   *** < 6.667E-05   < **NA/ND**   < 5.167E-06   < **NA/ND**
PALLADIUM     < 1.000E-03   **NA/ND**   **NA/ND**    ***  *** < **NA/ND**   < **NA/ND**   < **NA/ND**   < **NA/ND**
CADMIUM       < 1.000E-03   5.000E+01   1.000F+00    NO    NO < 2.000E-05   < 1.000E-03   < 1.550E-06   < 7.750E-05
INDIUM          NOT FOUND AS INPUT
TIN           < 1.000E-03   **NA/ND**   **NA/ND**    ***  *** < **NA/ND**   < **NA/ND**   < **NA/ND**   < **NA/ND**
ANTIMONY      < 1.000E-03   7.500E+03   2.000E+02    NO    NO < 1.333E-07   < 5.000E-06   < 1.033E-08   < 3.875E-07
TELLURIUM     < 1.000E-03   1.500F+03   **NA/ND**    NO   *** < 6.667E-07   < **NA/ND**   < 5.167E-08   < **NA/ND**
IODINE        < 2.000E-03   **NA/ND**   **NA/ND**    ***  *** < **NA/ND**   < **NA/ND**   < **NA/ND**   < **NA/ND**
CESIUM        < 1.000E-03   1.200E+06   **NA/ND**    NO   *** < 8.333E-10   < **NA/ND**   < 6.458E-11   < **NA/ND**
BARIUM          7.900E-02   5.000E+03   2.500E+03    NO    NO   1.580E-05     3.160E-05     1.224F-06     2.449E-06
LANTHANUM     < 1.000F-03   1.700E+06   **NA/ND**    NO   *** < 5.882E-10   < **NA/ND**   < 4.559F-11   < **NA/ND**
CERIUM        < 1.000E-03   5.500E+05   **NA/ND**    NO   *** < 1.818E-09   < **NA/ND**   < 1.409E-10   < **NA/ND**
PRASEODYMIUM  < 1.000E-03   7.700E+05   **NA/ND**    NO   *** < 1.299E-09   < **NA/ND**   < 1.006E-10   < **NA/ND**
NEODYMIUM     < 2.000E-03   **NA/ND**   **NA/ND**    ***  *** < **NA/ND**   < **NA/ND**   < **NA/ND**   < **NA/ND**
SAMARIUM      < 2.000E-03   7.900E+05   **NA/ND**    NO   *** < 2.532E-09   < **NA/ND**   < 1.962E-10   < **NA/ND**
EUROPIUM      < 1.000E-03   **NA/ND**   **NA/ND**    ***  *** < **NA/ND**   < **NA/ND**   < **NA/ND**   < **NA/ND**
GADOLINIUM    < 1.000E-03   **NA/ND**   **NA/ND**    ***  *** < **NA/ND**   < **NA/ND**   < **NA/ND**   < **NA/ND**
TERBIUM       < 1.000E-03   **NA/ND**   **NA/ND**    ***  *** < **NA/ND**   < **NA/ND**   < **NA/ND**   < **NA/ND**
DYSPROSIUM    < 1.000E-03   2.300E+05   **NA/ND**    NO   *** < 4.348E-09   < **NA/ND**   < 3.370E-10   < **NA/ND**
HOLIMIUM      < 1.000E-03   **NA/ND**   **NA/ND**    ***  *** < **NA/ND**   < **NA/ND**   < **NA/ND**   < **NA/ND**
ERBIUM        < 2.000E-03   **NA/ND**   **NA/ND**    ***  *** < **NA/ND**   < **NA/ND**   < **NA/ND**   < **NA/ND**
THULIUM       < 1.000E-03   **NA/ND**   **NA/ND**    ***  *** < **NA/ND**   < **NA/ND**   < **NA/ND**   < **NA/ND**
YTTERBIUM     < 1.000E-03   1.500E+04   **NA/ND**    NO   *** < 6.667E-08   < **NA/ND**   < 5.167F-09   < **NA/ND**
LUTETIUM      < 1.000E-03   **NA/ND**   **NA/ND**    ***  *** < **NA/ND**   < **NA/ND**   < **NA/ND**   < **NA/ND**
HAFFNIUM      < 3.000E-03   7.500E+04   **NA/ND**    NO   *** < 4.000E-08   < **NA/ND**   < 3.100E-09   < **NA/ND**
TUNGSTEN      < 3.000E-03   1.500E+04   **NA/ND**    NO   *** < 2.000E-07   < **NA/ND**   < 1.550E-08   < **NA/ND**
RHENIUM       < 2.000E-03   **NA/ND**   **NA/ND**    ***  *** < **NA/ND**   < **NA/ND**   < **NA/ND**   < **NA/ND**
OSMIUM        < 3.000E-03   **NA/ND**   **NA/ND**    ***  *** < **NA/ND**   < **NA/ND**   < **NA/ND**   < **NA/ND**
IRIDIUM       < 3.000F-03   3.000E+01   **NA/ND**    NO   *** < 1.000E-04   < **NA/ND**   < 7.750E-06   < **NA/ND**
GOLD          < 2.000E-03   **NA/ND**   **NA/ND**    ***  *** < **NA/ND**   < **NA/ND**   < **NA/ND**   < **NA/ND**
THALLIUM      < 1.000E-03   1.500E+03   **NA/ND**    NO   *** < 6.667E-07   < **NA/ND**   < 5.167E-08   < **NA/ND**
LEAD            1.000E-03   2.500E+02   5.000E+01    NO    NO   4.000E-06     2.000E-05     3.100E-07     1.550E-06
BISMUTH         1.000E-03   6.100E+03   **NA/ND**    NO   ***   1.639E-07     **NA/ND**     1.270E-08     **NA/ND**
THORIUM         3.000E-03   5.300F+03   **NA/ND**    NO   ***   4.762E-07     **NA/ND**     3.690E-08     **NA/ND**
URANIUM         2.000E-03   6.000E+04   5.000E+02    NO    NO   3.333E-08     4.000E-06     2.583E-09     3.100E-07
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                          EX1-01-10-SF

                SUBTOTAL INORGANIC DISCHARGE SEVERITY FROM THE EFFLUENT STREAM :


    SUBTOTAL DISCHARGE SEVERITY (HEALTH DMEG BASED) =       4.460E-04
    SUBTOTAL DISCHARGE SEVERITY (ECOL DMEG BASED) =        45.845E-04

                SUBTOTAL INORGANIC WEIGHTED DISCHARGE SEVERITY FROM THE EFFLUENT STREAM :


    SUBTOTAL WEIGHTED DISCHARGE SEVERITY (HEALTH DMEG BASED) =      < 3.457E-05
    SUBTOTAL WEIGHTED DISCHARGE SEVERITY (ECOLOGICAL DMEG BASED) =  < 5.553E-04
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